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[COMMITTEE PRINT]

THE FUTURE OF AVIATION

A COMPILATION OF PAPERS

(A SUPPLEMENT)

PREPARED BY THE

SUBCOMMITTEE ON
AVIATION AND TRANSPORTATION R. & D.

OF THE

COMMITTEE ON
SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES
NINETY-FOURTH CONGRESS

SECOND SESSION

Serial PP

VOLUME II



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CONTENTS

STATEMENTS

	Page
William M. Magruder, executive vice president, Piedmont Airlines-----	1
A. Scott Crossfield-----	16
A. Scott Crossfield-----	71
A. Scott Crossfield-----	89



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August 11, 1976

ORGANIZATION FOR AVIATION

I. Background

From the Federal Aviation Act's birth in 1958, until 1969 the FAA did, in fact, serve as a balanced focal point for the safety and operational regulation of airline/operators and manufacturers; while, at the same time promoting all forms of aeronautical progress. Some examples could be:

- . Initiation of the first jet service in the U. S. in 1958 and the development of safety, certification and operating rules.
- . Organization, funding and program management of the U. S. Supersonic Transport Development, a two-airplane experimental project, in partnership with the U. S. industry.
- . Initiation of a U. S. blind landing program that included experiments, a flying prototype and a joint FAA/USAF project on the USAF C-141 project.
- . Implementation of the VOR navigation system in the air traffic control system of the U. S. after much experimentation.
- . Refinement of the U. S. instrument landing systems to Category II requirements. This involved the development of certification rules and operational requirements for operators in poor weather, eventually including Category III blind landing certification of the L-1011.

- . The establishment of a quiet, short-haul transport office to stimulate small city service and possible city-center to city-center service.

Starting in 1971 with the Congressional vote to cancel the U. S. Supersonic Transport Development program to demonstrate two prototype-experimental airplanes, the FAA role in stimulating air transport and aviation progress has steadily diminished to its present status wherein such promotion is virtually non-existent.

Some examples of how the promotion role has been allowed to atrophy could include:

- . The quiet, short-haul development project office was abandoned in 1973 without any public reason offered.
- . Development of SST technology has been deferred almost 100% to the NASA. DOT/FAA has concentrated on ecology impacts and certification rules.
- . During the fuel embargo, the DOT/FAA team was selected by then FEA Administrator William Simon as the aviation focal point. Actions in DOT were non-existent and the CAB became the spokesman and focal point for civil aviation by default. The FAA played no visible role.

- . During the 1973 funding hearings for the USAF Advanced Medium STOL Transport (AMST), NASA and the executive office had to promote the civil air transport benefits in order to help get the program funded. FAA and DOT support activities were non-existent.
- . A DOT Policy Statement devoid of recognition of the need for a total system aviation focal point.
- . In 1973, when financing looked difficult for manufacturers, the CAB had to support the industry proposal for financing new transports without help or support from the DOT/FAA. This problem is now crucial, and is widely recognized even by DOT but without meaningful action by DOT except for their counter productive "regulatory reform" actions.
- . A regulatory reform effort that reflects DOT staff studies ignoring FAA/CAB/industry expertise and circumventing the FAA organization almost totally.
- . The current efforts to obtain funding for a joint civil/DOD program that will produce an efficient, quiet and clean small city service jet transport had to struggle from 1971 to 1975 with DOD, NASA and executive office support alone, even though this project was named in the DOT CARD report of 1971. This lack of DOT support was rectified in 1975, but even today FAA involvement is minimal, if it exists at all.

FAA emphasis, since the late sixties, has been primarily aimed at improving the air traffic control system, airport improvements and expansions, reducing noise and community impacts and regulatory operating and certification standards; all worthy objectives in themselves but almost wholly devoid of the principal problems facing commercial aviation today, which are:

- 1) Lack of financial viability and credit with lenders.
- 2) Fuel embargo impacts.
- 3) Poor earnings.
- 4) High costs of operations and certification.
- 5) The need for more productive systems and equipment.
- 6) Unrestrained labor practices in scheduled airlines.
- 7) A proliferation of international competitors that are subsidized and compete unfairly against our international carriers and manufacturers.
- 8) An ill-advised and poorly-timed regulatory reform movement.

II. Purpose

The FAA image as "Mr. U. S. Aviation" will never emerge if it fails to respond to these opportunities/problems. The purpose of this paper is to outline a management system that will ensure that the FAA does respond with adequate measures to make its responses efficient and effective, leading to its accomplishing a balanced role as the U. S. aviation focal point. Its overall aim is to balance the respective considerations of:

- . Safety
- . Regulation
- . Economic health of all parties
- . Social impacts upon all parties, and the
- . Promotion of a responsive and healthy total aviation system in the U. S. transportation system.

This system supposedly operates like private industry and so the arguments about it would be:

Pro:

- 1) Model agencies submit programs, budgets and manpower levels through DOT staff for approval.
- 2) Priorities and policy established at Secretary and staff level.
- 3) Implementation left to model administrators.
- 4) Interagency coordination as established by the Office of the Secretary.

Con:

But the federal government does not and cannot operate like private industry. The staffs are not "old timers" with a system of promotion so that experience, training and expertise sits in the staff levels. Most of the "experts" are in the agencies and in industry. The staff levels come from outside business with each new administration and are of varied experience and talent, not always or even usually up to the 20-year agency expert. Also, political consideration and bureaucratic pressures influence decisions out of proportion to the simple job

description. This includes personnel placement, especially in top-grade levels. Some examples of poorly conceived staff efforts:

- + 300 mph train experiments in Colorado.
- + Passenger train subsidies in competition with other short-haul modes.
- + DOT staff studies done without model agency knowledge even though in their area of responsibility and expertise.

In other words, the present organization is virtually a guarantee of either "departmental strife," if a strong model administrator is appointed; or, a demise of expert input if a weak administrator is appointed. From the birth of the DOT to 1973, the FAA-DOT staff relations were already being politely called "strained." Since 1973, no strong innovative, imaginative leadership has evolved from the FAA or DOT for aviation.

- 1) The FAA Administrator needs a DOT staff supervisor who is as expert in aviation as he is. The Secretary and Undersecretary should accomplish the liaison with the executive office regarding policy and plans. Interagency coordination needs expert attention.

Solution: Create three slots directly under the Secretary/Undersecretary. They would be Deputy Undersecretary for Air, Ground and Water. It may, at first glance, look like the Deputy Undersecretary jobs for Air, Ground and Water would be unbalanced; however, when outside agencies are considered, the balance becomes evident. For example:

<u>Air:</u>	FAA	FEA	Etc.
	NTSB	DOD	
	CAB	NASA	
	State Department	NSF	

<u>Ground:</u>	Federal Rail	Etc.
	Urban Mass Transit	
	Federal Highway	
	Department of Interior	
	Rail Retirement Board	

<u>Water:</u>	Coast Guard	Etc.
	St. Lawrence Seaway	
	U. S. Navy	
	NOAA	
	Federal Maritime Commission	

The FAA Administrator could have both jobs if the Secretary found this to be advisable. Such a man should be versed in airline/manufacturer/general aviation operations, the economics/financing of the industry and should be so eminent and expert that personal gain cannot be attributed to his accepting the job. This organization will put the Deputy Under-

secretary-Air above the staff functions of:

- + Public Affairs
- + Policy and International Affairs
- + Urban System and Environment
- + Research and Technology
- + General Counsel
- + Legislative Liaison

so that the staff studies, integration of a total air transport system and legal and political considerations will be done under an expert and not on top of the best available experts as a restraint. The emphasis will be on decision movement and not blockage. Decisions will be on broad consideration and not narrow interests.

- 2) The FAA, since about 1969, has not had an adequate system/economic/benefits analysis group. The office was disbanded by the Undersecretary in 1970, so that his office could dominate the analysis and policy efforts. The capability should be reconstructed.

Solution: A staff office of at least ten top quality systems analysis experts should be added to the FAA staff. This function should be so defined as to not clash with the DOT Policy and Plans Office but instead to fund and/or accomplish such systems benefits, economic and other analyses as to form a basis for recommendations by the Administrator. The international studies and broad policy analyses should continue to be done by the Policy and Plans and International Analysis Office but with overview by the Undersecretary for Air.

- 3) The FAA, since the SST decision, has deliberately stayed away from prototype, experimental or demonstration airplane programs.

Solution: This policy should be publicly abandoned and a line function office established called something like the Development and Demonstration Division. It would be on a level with the Divisions of Safety, Maintenance and Operations, Flight Standards, etc. Its budget should reflect priorities in stimulating the development of all forms of identifiable needs for air transport such as: SST's, air traffic control systems, general aviation systems and V/STOL. It would not develop production articles but would serve to provide funding for the next step after research to demonstrate the viability of a candidate system economically, operationally, environmentally, etc. Its programs would serve to reduce risks to levels that the private sector could fund, to demonstrate feasibility and to demonstrate concepts that might otherwise not be accomplished by the industry.

V. Costs

The cost of the three proposals would probably not exceed the following:

- | | |
|--|------------------------------|
| 1) Office of Undersecretary for Air, Land, Sea | \$300,00 per year |
| 2) Office of Systems Analysis | \$5 million per year |
| 3) FAA Development and Demonstration Division | \$500 million to \$1 billion |
| *Some of this could be NASA budget. | per year* |

JOB DESCRIPTIONS AND RESPONSIBILITIES1. Undersecretary for Air -- Responsible:

- . To the Secretary of Transportation for all policy, plans, implementation and interdepartmental, industry and international aviation matters as related in the following responsibilities:

- + For the initiation, review, approval of analysis, approval of policy development, plans and programs associated with intermodal transport systems affecting air transport and related modes of transport.

- + For the initiation, review and approval of all aviation programs, budgets, manpower levels, and congressional testimony.

- + For the review and coordination of other departments' aeronautical programs which could relate to U. S. national air transport policies. This would include, but not be limited to:

- | | |
|--------------------------|--------------------------|
| . National Academies | . FEA |
| . CAB | . Department of Treasury |
| . State Department | . Department of Interior |
| . Department of Defense | . Smithsonian Institute |
| . Department of Commerce | . NSF |
| . NASA | . NTSB |
| . OMB | . Justice Department |

- + For the development of a national aviation/air transport policy as incorporated into the departmental national transportation plan and policy.

2. Federal Aviation Administrator -- Responsible:

- . For regulating air commerce to promote its safety and development.
- . For achieving efficient use of the navigable air space of the U. S.
- . For promoting, encouraging, developing and operating a common system of air traffic control and air navigation for both civilian and military aircraft.
- . For promoting the development of a national system of airports.
- . For promoting, investigating, developing and demonstrating new technology associated with the above aims in concert with the Department of Transportation National Transportation Plan.
- . For formulating a national aviation/air transport plan to be incorporated into the National Transportation Plan.
- . For coordination with other governmental departments, agencies and other national governments as directed through the Undersecretary for Air of the Department.

3. Director, Systems Analysis -- Responsible:

- . For the formulation of economic analysis, cost benefit analysis, inter-modal impact studies and recommendations regarding all new systems development, stimulation and demonstration.
- . For the coordination of all inter-modal systems analysis, cost-benefit studies and value analysis performed by the Policy and Plans and International Affairs Office, and other agencies, to assure that the aviation impacts are properly evaluated and/or areas of disagreement spotlighted for resolution by the Administrator and/or the Undersecretary for Air.

4. Director, Office of Development and Demonstration -- Responsible:

- . For justification of funding, programming, and manning of projects designed to assure that the National Aviation Plan objectives are attained in a timely and efficient manner.
- . For implementing those programs approved by the Administrator, the Undersecretary for Air, and the Secretary of Transportation. All program implementation to use to the maximum extent practicable a competitive bid system, the other governmental research facilities available in NASA, DOD, etc., and the private enterprise system capability and resources. In-house development will be used primarily as a last resort technique when the private sector cannot by any practicable means attain the proper goals.

- . For constructing a National R&D Aviation Budget system and report that will take into account, to the maximum possible extent, the R&D that is civil aviation oriented in other agencies such as DOD, NASA, NSF, Bureau of Standards, the universities and the private sector. This National Aviation Budget/resource annual report to be utilized in informing all affected agencies, OMB, congress and the public of the impacts of additions and deletions to authorized programs in terms of risks, date of implementation, costs and performance.
- . For evaluating the national U.S. aeronautical R&D facilities available for R&D and annually recommending their status for improvement, replacement and/or deletions.
- . For evaluating the national U.S. aeronautical R&D manpower needs as compared to the National Aviation Plan and coordinating the need with all the appropriate agencies such as NSF, the National Academies, HEW, etc.

NATIONAL
CIVIL AVIATION AND AERONAUTICAL
RESEARCH AND DEVELOPMENT
A LIMITED REVIEW

Submitted to

The Honorable Dale Milford, Chairman
Aviation and Transportation R&D Subcommittee
House Committee for Science and Technology

by

A. Scott Crossfield

May 17, 1976

SECTION I

FAA RESEARCH, ENGINEERING AND DEVELOPMENT

SECTION II

NASA AERONAUTICS RESEARCH AND TECHNOLOGY

NATIONAL
CIVIL AVIATION AND AERONAUTICAL
RESEARCH AND DEVELOPMENT
A LIMITED REVIEW

SECTION I
FAA RESEARCH, ENGINEERING AND DEVELOPMENT

FORWARD

Section I of this report is intended to be a scholarly, critical, and uninhibited review of FAA R&D proposals and facilities utilization as laid against a probable prognosis of the future requirements to the turn of the century. The real world of air traffic management facing the FAA cannot be shut down for refurbishment nor does it permit mistakes of trial and error. Any developmental improvements must be evolutionary and implemented at the rate that the system will accept. Long range plans must be in the form of hard design specifications with several years lead time. The imperative need for major systems improvements and change in direction for future requirements cannot be over emphasized. It is intended here to encourage stepping up to the hard decisions necessary to attain what we must have to sustain the best balance in air transport capability for the good of the country.

The adequacy and efficiency of the Air Traffic Management System is absolutely pivotal for the health of the domestic air transport system. The prosperity of the domestic air transport system is essential to the health and prosperity of the whole U.S. civil aviation endeavor.

CONTENTS

FORWARD	
CIVIL AVIATION R&D IN THE NATIONAL SCHEME	1
Domestic Air Operations	1
The Status of Aviation Planning	1
Whither Goes the Nation ?	2
Transportation Policy - Oil or Sand	3
Turbulence for Air Transport Plans	3
The Domestic Questions	5
The International Questions	5
CIVIL AVIATION AIR TRAFFIC MANAGEMENT	7
The Air Traffic State of Affairs	7
2nd Millennium Air Transport Network and Air Traffic Control	8
The Unique Character of the Federal Aviation Administration	10
FAA FY 77 PROPOSED R&D, LIMITATIONS AND MISSING ELEMENTS	12
FEDERAL AVIATION ADMINISTRATION RESEARCH AND DEVELOPMENT LABORATORY CAPABILITIES	18
CONCLUSIONS AND RECOMMENDATIONS	24
APPENDIX I, Determining Costs of ATC System Delays	
APPENDIX II, Block Time versus Aircraft Performance	

CIVIL AVIATION R&D IN THE NATIONAL SCENE

DOMESTIC AIR OPERATIONS

United States civil aviation seems to be locked into a cyclic catch up ball game that periodically spurs the nation to action. In 1915 we created the National Advisory Committee for Aeronautics, in 1926 it was the Air Commerce Act, in 1938 the Civil Aeronautics Act was passed, and in 1958 came the Federal Aviation Act. The Department of Transportation Act of 1966 did not arise from aviation pressures but did preempt and veil the 1967-69 air traffic crisis. The Airport and Airways Development Act and Revenue Act then came along in 1970. This act taxed the user for funds that today remain about half idle under many constraints. From the funds that have been expended, prosperous hubs have profited further and undeveloped areas have remained neglected.

All of these actions were generally associated with social and economic shifts of one form or another that were belatedly recognized. These governmental actions played vital roles but usually were to "catch up". It is axiomatic that timely aeronautical R&D is the most economical way to pay for the future if we are wise enough to predict that future with any accuracy. It is also axiomatic that timely application of aeronautical R&D is crucial in its role of the future. It only costs a great deal more when we afford delays. The pressures today are very high for some visionary action. Where do-we now stand ?

The Status of Aviation Planning

There have been numerous studies of civil aviation and its future prospects since WW II beginning with the Finletter Report of 1948. Since then, the continued proliferation of such studies rather proclaims that an acceptable and believable basis upon which we can arrive at a national plan for long range civil aviation development has not yet been offered.

Generally, all of the studies include extensive statistics that prove the importance of aviation. All decry the apparent inattention of high level government to the importance of aviation in the national

- 2 -

scheme of things. All, in recent years, have had the same shopping lists of specifics that must be addressed. And, all seem to share the same fate of having little or no impact upon the attention of the many agencies that conduct the nation's business.

Common characteristics of studies in current issue are the overwhelming recourse to statistical justifications and the apparent fear of acknowledging empirical indicators and intuitive judgement. Wise and experienced judgement appears to concede to the safe non-judgement of statistical techniques. It would seem to require a philosophical grasp of complex social/economic structure to wisely forecast any part of the nation's future, and in addition, an intellectual recognition of historic and current trends.

This argument purports to offer another view of the course that civil aviation may follow into the turn of the century. These concepts are not necessarily invented here nor are they new. To lay a basis to assess the future of civil aviation, observations of where its customer is going are in order.

Whither Goes the Nation ?

A legacy of the 19th century industrial revolution was the large industrial city with its mass labor concentration. The depression of the 1930's, the dust bowl, the mechanization of agriculture, and the concentration of WW II industrial expansion compounded the mass migration to the urban labor markets until 90% of the nation lived on 7% of the land. The legacy of that 19th century disease then became almost all of the crimes that are committed against the nation. Congestion, pollution, waste of time and energy, criminality, dehumanization, noise, filth, and poverty, name it, have almost brought the country to its knees, divided it, and captured its attention from the normal course of productive enterprise. We no longer need these oversized cities based upon 19th century transportation and technology.

The large industrial city structure of the nation has reached maturity and seeded its own demise. The people have recognized this by natural instinct and have already begun the move to take their labor, their business, and their future back to the smaller cities and towns. An interim stop is often the suburbs. Their government seems to have

- 3 -

failed to recognize the signs. Policy rather resists the natural tide by pouring huge resources into perpetuating the large cities in their present form. And so it goes with transportation policy.

Transportation Policy - Oil or Sand

Related to big city structure is transportation and in a similar vein transportation policy to wit:

* Government programs are aimed at forcing people into mass transportation systems. What more than overwhelming historic evidence do we need to know that they don't want them, won't use them if they can help it, and that only massive infusion of subsidy by non-benefiting taxpayers will sustain them.

* Government programs spend great sums to force people to use trains for travel. They don't want to do it, won't do it, and passenger trains will survive only with heavy non-benefiting taxpayer subsidy.

* Government policy aims at forcing people out of their automobiles. They don't want to be and they won't be.

The argument here is not whether these things are good, but that they seldom work. A classic example is the scheme of dedicated bus and car pool highway lanes so highly touted by DOT. To be observed, when approaching the Nation's capital during rush hours, are two virtually empty highway lanes given over to buses and car pools. Three totally congested and stalled lanes are allowed to the "others". The denial of two fifths of the highway capacity to major flow requirements under claims of efficiency and conservation defies common sense. Americans are just not amenable to structured behavior.

And so it goes with civil air transportation policy: the attempt to mold it into a preconceived form that it probably will not take.

Turbulence for Air Transport Plans

The DOT practices a policy that public transportation under, say, 500 miles trip length is not within the province of aviation. This in the face of overwhelming evidence of public preference. More than 80% of air transport demand is for under 500 miles. The mood of the country to disperse signals even more short haul demand in the future, though with different network distribution. The DOT National Transportation Policy specifically refers to aviation's role in "long haul", "long distance", etc. several times. Its single reference to short haul

- 4 -

is in a negative comparison.

The FAA plans, ADAP, and much of NASA's plans are devoted to resolve existing congested center problems within the existing system. The concentration of attention to the congested hub problems without equal attention to alternatives and the coming needs of the rest of the country only serves to attract more congestion. The existing air traffic system simply cannot absorb additional traffic arising from this distortion. With the growing inadequacy of the regional air transport network unplanned systems proliferate with a new set of problems.

The exponential growth of commuter/air taxi, business aviation, and much of the rest of general aviation is much a result of having no other way to get about the country or to get in to the scheduled carrier system. Over 70% of the traffic at the 24 hub airports originates or goes less than five hundred miles away. The bulk of this traffic is connecting traffic. The hubs have reached or are approaching saturation and no amount of investment in the existing system can raise their capacity significantly in the foreseeable future. It is timely to recognize the limitations of cities and hubs and to begin to restructure the air transport system in keeping with the developing national trends.

The failure of the air carrier system is the driver for general aviation growth much as the failure of ground carriers drove people into automobiles. This can portend a similar chaos. Fortunately it is not inevitable except that we may make it so.

Several observations can be made that formulate a basis from which we can attempt to determine a common sense balance of aeronautical R&D requirements:

- * FAA and NASA civil aviation R&D resources are almost entirely aimed at resolving existing problems and their extension into the future. This is undoubtedly good in the sense that

- * The maze of existing problems must, at least, be relieved, if not solved, to avoid so crippling the aviation industry that it loses the momentum necessary to carry it into the turn of the century with maximum advantage to the country, however,

- 5 -

* Efforts to resolve existing problems, only, may very well cloud recognition that those very solutions, by themselves, work against the needs of the future in that they tend to perpetuate conditions against the natural tides, further,

* The direction the country prefers and in which it actually moves may have little to do with the government process except that it may be catalyzed or hindered by the government process.

It could be effectively argued that the underlying problems of civil air transport are quite parallel to those of the large cities. In some ways the economics of the two are too similar for comfort. However, the aviation community has often demonstrated its resilience and vision in the past. Perhaps a golden opportunity presents itself for aviation to be the leading edge of a smoother transition into the future.

The Domestic Questions

If we accept the premise that the signs are real and the future holds a substantial probability that people and business will migrate back to small cities and towns then:

- * Is it good ? Should it be encouraged ?
- * Will, say, a 10 to 30% reduction in large city population yield the breathing room necessary to make large city problems manageable ?
- * Will this cause a related effect upon air transport congestion and permit a shift from the total attention paid to those problems ?
- * Does acceptance of this thesis imply that domestic air transport has a cardinal role in the redistribution of industry and people ?
- * Does this suggest that a restructuring will develop in the air transportation network ?
- * Will varied air vehicle development, now suppressed, flower ?
- * Do these things then define the complexion of civil aviation R&D requirements ?

This report argues that the answers to those questions are "yes". However, civil aviation R&D does not pertain only to the tools and systems to accomplish those ends.

The International Questions

There are additional hard questions that must be asked and answered and followed by hard decisions. For industrial health and pro-

- 6 -

sperity is it mandatory to:

- Maintain international leadership in all phases of civil aviation technology ? and
- Make secure international leadership in the marketplace for transports, SST's, V/STOL's, helicopters, general aviation aircraft, avionics, GSE, and all related products ?
- Do these questions define R&D requirements ?

This report sustains the view that the answers to those questions are unequivocally "yes". It also argues that both sets of questions and answers are supportable by a common R&D program.

CIVIL AVIATION AIR TRAFFIC MANAGEMENT

The Air Traffic State of Affairs

The Airport and Airway Development Act of 1970 says: "The Congress hereby finds and declares-- The Nation's airport and airway system is inadequate to meet the current and projected growth in aviation". That statement is still true and the situation may in fact have deteriorated . The rapid growth of ATC delays around 1968 has slowed but still continues to escalate. The true picture is obscured for several reasons: artificial ceilings at major hubs, temporary reductions of schedules through capacity agreements and because of fuel costs and recession, and the absorption of delays into schedules. The FAA delay data, by virtue of the method by which it is gathered, understates the true case by perhaps an order of magnitude. Carriers have realized less than half of the increase in performance brought about by jets because of the air traffic system (see Appendix II Section I). Yet, it is not the airspace that is crowded, only the air traffic system by virtue of its design.

The non-productive flying of the scheduled carriers alone, wholly due to the ATC System, may currently approach costs and/or losses of a billion dollars a year. The methods by which that estimate is made are discussed in Appendix I Section I. In an industry that shoulders such severe economic pressures it is obvious where attention should be focused. Unless some imaginative system changes are made the future prospects are even grimmer.

It should be recognized that the source of the problem generally lies outside of the FAA purview. The concentrated hub and spoke air transport network is a natural progeny of the growth of the large cities and suffers from the same consequence of too much concentration. Only one CAB airline has refused to fall into the trap.

If the thesis that dispersal of population and industry from urban centers is valid, then it portends a favorable situation for air transport. The advantages to be gained depend inversely upon the degree of resistance to change of the industry and FAA. The FAA can lay the ground-

work to transition into the next phase as we head toward the turn of the century. However, the current level of pertinent R&D is probably only half enough and fails that responsibility, not only in amount but in direction also.

2nd Millennium Air Transport Network & Air Traffic Control

A major change of the air traffic network as we go into the turn of the century will be its dispersal from the untenable concentrations of the large hub and spoke structure. The air transport system will follow the flight of people and industry to the smaller cities and towns. Perhaps it should lead them. Only the state of Ohio has had that kind of vision and demonstrated it. At any rate there will be little increase in hub traffic. Foreseeable resources and technology cannot produce large increases over present limits. Flexible frequent access to all parts of the country by scheduled carriers will characterize the natural outgrowth of the now expanding commuter/air taxi and business traffic. The pipe dream of 1000 passenger leviathons, as old as aviation itself, can serve only a special purpose in the general picture. Already the cost and size of air transports, coupled with the battle for high load factors through reduced schedules, has reduced the public convenience of access to frequent flexible scheduling. The growing productivity of the smaller cities and towns will create the demand for more mobility. This demand will call for convenient, high frequency schedules.

Whether the foregoing prognosis has merit or not, in any event, the technical and operational characteristics of the air traffic system will evolve into a predictable form if we capitalize on available technology with common sense:

- * Nearly all weather access to nearly all airports with nearly all the same safety is within our capability, and must be made available to nearly all aircraft of all types. Since ground based provisions for such a capability are prohibitively costly, this clearly calls for on-board capability available to the extent needed and provided by the user at his cost. With such a capability the ATC system falls into a natural pattern of two complimentary major elements:

- 1) Airborne: in which pilots are to be held wholly responsible for the safe conduct of inflight operations with accurate three dimensional

- 9 -

positioning capability, independent of ATC inputs, and be capable of navigating to any other position in airspace, independent of ATC participation. This clearly requires that, excluding consideration for other traffic, airborne equipment provides safe enroute and terminal guidance without reliance upon traditional precision ground installations and radar guidance. This then creates the firm requirements for an accurate common navigation system to cover all geographic areas and altitudes.

2) Ground based: in which controllers will utilize independently generated surveillance data to monitor and sort out all traffic, to regulate and instruct all traffic flow to avoid potential conflicts in a timely way. In short: direct traffic. This implies elimination of radar vectoring except as a backup, and elimination of controller responsibility for aerial navigation except as a backup. The proposed UG3rd (UpGraded 3rd generation system) by and large contains the elements of this ground capability, though, the UG3rd is not intentionally designed for a distributed responsibility system.

Clearly the elements of what the CARD (Civil Aviation Research and Development) study refers to as ground strategic control/ airborne tactical control are proposed here. Further advancing steps follow in natural order. The equipments that are required for the airborne and ground systems, at this stage, also provide the capability for cooperative interchange of data between air and ground. Once redundancy and single point failure modes are accounted for, a safe cooperative system will permit further substantial reduction in radar requirements. Beacons and DABS concepts and their derivatives are crude examples of cooperative systems. Such potential major cost savings must be responsibly pursued.

The capability and the reliability of the airborne equipment is paramount in the specification, and the needs imperative:

- * Without reliable total positioning and navigation information available, along with controller instructions, the pilot cannot be held responsible for the safe conduct of the flight.

- * Without accurate airborne navigation capability we are denied IFR access to most of the nation's airports for several more generations.

* Following right on the heels of conventional traffic's expanding requirements is the whole evolving era of V/STOL systems in the air traffic scheme. Total airborne capability is absolutely essential to realize the benefits of this development, and common sense dictates that equipment commonality is also essential.

* Special service operations also vitally need an accurate common navigation system, ie: search and rescue, off shore helicopter operations, Alaska, etc.

The constantly recurring demand for an accurate on board three dimensional navigation and terminal guidance system keeps cropping up in this review of future need. Need for consideration of the fourth dimension (time) follows closely these basic requirements. High priority R&D appears mandatory.

The Unique Character of the Federal Aviation Administration

The FAA is isolated and uniquely different from its parent DOT and all other agencies in the governmental structure. Of most of the government agencies it is one that is completely absorbed in the hourly operations of the nation. It also, probably, is the only agency that is held completely accountable for its every action. In assuring the safe flow of air commerce it, to a large degree, reaches into the daily lives of almost every citizen on a real time basis. Because of the isolated and unique character of the FAA's daily, hourly, minute by minute responsibility it shares with no one the expertise in its complex operations. Even the using pilots have only a cosmetic view of the system let alone an understanding of how it all works.

It is because of this that the many studies and analyses by a variety of academicians, blue ribbon committees, transportation experts, etc. have generally resulted in superficial generalities and few usable hard recommendations. The CARD study is one exception that brought a number of considerations into perspective. The FAA itself has been so preoccupied with its immediate tasks that it has fallen behind in fully anticipating its own future requirements. Where it has attempted to get attention to its problems it has found itself buried under layers of government, each with their own axe to grind and unmindful of the

of the air transport role in the national scheme of things.

One result of this situation is that FAA has fallen into the posture of arguing only the obvious and has despaired of attacking the future with effective vigor. The "oil the squeaky wheel" syndrome prevails. For instance: the FAA 1973rd plan has many elements to meet part of the future requirements as discussed above. It has been around for some years, it is still a paper exercise, it is not proposed for funding for implementation, and the hour has grown very late.

The FAA proposed FY 77 attenuated "core" program can only assure that the deterioration of safe and efficient air traffic flow will continue to totally unacceptable levels of stagnation with the consequent drag on the whole economy. The nut of the problem is the absence of vigorous policy, leadership, and executive level support.

FAA FY 77 PROPOSED R&D, LIMITATIONS, AND MISSING ELEMENTS

The general planning done within the FAA, by and large, does a credible job of defining R&D activity necessary to resolve current, near term, and long range requirements. However, by the time these plans see the light of day, and are presented to Congress for funding, they are so emasculated as to appear futile. The FY 77 proposal for funding may just barely bring relief to today's situation with little or nothing for ten years, twenty years from now. The FAA attenuated "core" program to be funded is just plainly irresponsible. That harsh statement is borne out simply by what is left out from the UG3rd plan which in itself is "barebones" if we wish for a fighting chance to prevail in the future without crippling the industry further. At the present time some 15 to 20% of the IFR flight operations East of the Mississippi River are non-productive, this wholly attributable to the ATC system (see Appendix I Section I). If nothing changes and there is no growth, the proposed "core" program may eliminate some of that but do little more. What of the future? This situation breeches the faith of the user paying into the Airport and Airway Trust Fund and thwarts the intent of the Airport and Airway Development Act.

The accompanying chart (p. 17) lists thirteen line items of the FY 77 R&D proposal according to one FAA breakdown. A subjective assessment of where the benefits fall is illustrated by the length of each bar. Consideration was given to an admixture of economics, traffic, application, need, use, exposure, now, near term, and future.

Not at all surprising is that the hubs and the trunks reap the lion's share of the benefits. Perhaps a brief review of each is in order:

1) Aerosat. The Aeronautical Satellite program claims 6% of the year's resources, has little domestic contribution, questionable trans-Atlantic contribution, and based upon hard national operational priorities is of questionable value.

2) Automation comes in many forms, claims 24% of the budget, and is adjudged very high in priority. All phases of flight data acquisition, processing, presentation, ground/air/ground communications and data

exchange, and traffic flow planning are a crucial need now. Here we can harden soft spots in the system, relieve manual overloads, enhance sector handoffs, and in general smooth the flow of traffic. Automation as planned improves total ability to plan and sort out traffic, but it is hard to see where it will significantly contribute to increased traffic capacity at saturated hub airports for the future.

3) DABS. The Discrete Address Beacon System claims 14% of the budget and FAA bets heavily that it is the panacea of the future. In conjunction with automation, it provides improved quality surveillance data, air to ground data link, and as an adjunct to the Radar Beacon System (ATCRBS) permits automated ground based conflict detection, reducing the potential of mid air collisions. This is a "now" requirement, in spite of its limitations, in lieu of anything else available until a modernized plan materializes.

4) ASA. Airborne Separation Assurance claims 3% of the budget to investigate viable alternatives for collision avoidance systems. This has a safety priority and is congested area oriented.

5) Wind Shear claims 3% of the budget and is a safety item.

6) WWAS. Wing Vortex Avoidance System and Vortex Advisory System promise to permit reduced separation and improvement in landing flow rates in congested airports. Another safety priority.

7) ASTC. Airport Surface Traffic Control with 2% of the budget improves efficiency and safety of airport taxi traffic. Here is an essential requirement for Category III systems in the future.

8) MLS. Microwave Landing System with 20% of the budget represents the first new technology application to improve operations in many years. Like ILS, MLS promises only major airport applications for many years. If paralleled with a compatible small airport system (see comments on Interim MLS below) will be most effective in increasing traffic flow and safety in the system. Cost effective analyses indicate appreciable major airport traffic flow improvements it is claimed. MLS is considered high priority.

9) RNAV. Area Navigation concepts rate a minuscule fraction of a percent of the budget. RNAV technology offers the largest advantage, to all users, of any of the other line items, for both near and long range requirements. Carriers, manufacturers, and NAFEC have invested

large amounts of money and effort in demonstrating large potential advantages with RNAV. Much of the enroute and terminal area unused airspace is made available with RNAV technology. Significant increase in capacity and reduction of delays has been demonstrated. RNAV is essential to growing helicopter requirements. For some unfathomable reason the FAA is determined to frustrate all of these efforts, and thus fails in performance of its responsibility to the user in this area. (see Accurate RNAV discussion below) Top priority.

10) FSS. Flight Service Station automation rates 6% of the budget. Essential flight service requirements are growing with the growth of general aviation. The service is essential and can only be provided economically with considerable automation of access. This is the only significant line item that looks to other than hub type problems. High priority.

11) Systems Engineering and Long Range Research represents a variety of technological and system studies to explore alternatives for future requirements, and at 6% of the budget is adequate only if truly objective.

12) Airport/way Technology rate 12% of the budget. The prospects of new or expanded airports, where needed in the foreseeable future, are pretty grim. Therefore, maximum effort is needed to design improvements to existing airports to attain maximum available capacity. Additionally, durability of runways and taxiways, and their out of service maintenance times must be improved to the same end. High priority.

13) Aviation Medicine is discussed in another section.

Of the above, ten operational line items will become part of any future traffic system to the turn of the century. Seven are aimed at immediate hub type problems and contribute little more to satisfy the long range requirement to open up the rest of the country with forecast needs. Only MLS, if accompanied with a compatible low cost small airport version, has substantial long range contribution to the nationwide system requirement.

The 14th item on the chart, not a proposed budget line item, is the Compatible (with MLS) Interim Microwave Landing System, so called. A compatible limited system that, because of that limitation, can be quickly made operational and be relatively cheap, can make a very im-

portant contribution to the long range plan while serving a near term requirement. Interim systems are not immediately needed at major airports now served by ILS, but are needed at many airports beyond the 400 with ILS. Therefore, if costs permit, near term interim installations, utilizing airborne equipment that will be compatible interchangeably with both systems (MLS and Interim MLS), should be installed at all possible VOR airports. Thus, when ILS is replaced with MLS, along with the Interim MLS installations we will for the first time ever begin to have an adequate number of precision instrumented airports. A firm plus that argues that very high priority should be given to early development and installation of Compatible Interim MLS. The FAA Small Community MLS is claimed to meet all of these requirements and its development should be accelerated with or without waiting for ICAO blessing. The current "Interim Standard MLS" (ISMLS) allegedly does not meet essential compatibility requirements. Variety in incompatible or semi-compatible precision landing systems should be avoided if at all possible.

Another missing element of the FAA R&D proposal is Accurate RNAV technology (15th item). By far the most promising technology to open up use of all airspace, to all users, in all geographic areas, with IFR terminal guidance available to all runways, is the concept of Accurate Area Navigation. Carrier and industry efforts to develop RNAV applications have been thwarted at nearly every turn by the FAA. In spite of this, some carriers and many general aviation aircraft utilize RNAV to the limited degree permitted anyway. RNAV systems currently available have all the capability to provide the pilot with all the information necessary to hold him responsible for the tactical operation of his airplane under most circumstances. This is not the case with the present ATC system. Controllers who understand the use of RNAV are outspoken in claiming that their workload is considerably reduced with its use. Perhaps here is the clue to the FAA resistance to RNAV oriented traffic control.

The UG3RD system does not contemplate bringing the pilot significantly into the air traffic management decision-making loop. In looking to the future design of the ATC system, perhaps the single most decisive question to be answered is the extent to which traffic manage-

- 16 -

ment should be distributed between the pilot and the controller. Should the pilot be able to play an active part in the traffic management process, or just a passive role? Even further, should a new generation of cockpit instrumentation, such as traffic situation displays, be developed to give the pilot redundant capabilities for the purpose of traffic separation assurance and spacing? RNAV opens up all of these questions.

Accurate RNAV capability, with no line-of-sight restrictions, will open up all airports and helicopter pads for IFR capability with the resultant positive impact on all classes of air transportation.

The joint Military service NAVSTAR is one potential candidate for source data for civilian Accurate RNAV. For instance: if the NAVSTAR is provided by the Military, if the NAVSTAR meets its specified accuracy and coverage, and if the cost of the civilian airborne equipment is acceptable, then the positive impact on domestic air traffic will be mind-boggling. The potential savings in ground system costs alone will be monumental. The immediate requirement to develop civilian application of this technology is urgent.

GENERAL A 1002

CERTIFIED GENERAL

BROOKLYN

FY 77 FAC

- 17 -

FY 77 FAA R & D		BENEFITS				CERTIFICATED CARRIERS		GENERAL AVIATION	
LINE ITEM	% OF BUDGET	HUBS	MAJOR CITIES	SMALL CITIES, TOWNS	TRUNKS	REGIONALS, NON-SCHED	AIR TAXI, COMMUTERS, BUSINESS	OTHER, GENERAL AVIATION	
AEROSAT	6%								
AUTOMATION	24								
DABS	14								
ASA	3								
WIND SHEAR	3								
WVAS	1								
ASTC	2								
MLS	20								
RNAV	41								
FSS	6								
SYS ENG & LOW RAD RES	6								
AIRPORT/WAYS TECH	12								
AV MEDICINE	2								
**COMPAT IMLS	NIL								
**ACCR 3D RNAV	NIL								

* NOT FY 77 LINE ITEM

** COMPATIBLE IMLS = (OR EQUIVALENT) FAA SMALL COMMUNITY MLS

DISTRIBUTION OF FAA R & D BENEFITS

FEDERAL AVIATION ADMINISTRATION RESEARCH AND DEVELOPMENT
LABORATORY CAPABILITIES

FEDERAL AVIATION ADMINISTRATION RESEARCH AND DEVELOPMENT
LABORATORY CAPABILITIES

In 1957 President Eisenhower recognized the serious aviation facilities problems confronting the nation as a result of the rapid technical advances in aviation and the remarkable growth of the use of air transportation. In May of 1957 the results of a study dealing with this problem were published. The report stated:

" An independent Aviation Agency should be established into which are consolidated all the essential management functions necessary to support the common needs of the military and civil aviation of the United States."

The urgent need to modernize the airways prompted a further recommendation for a plan to include creation of an Airways Modernization Board. One of the agency's responsibilities was to establish "a national experimental activity---". Public Law 85-133 established the Airways Modernization Board. By April 1958 the board selected the 5000 acres and facilities of the Atlantic City Naval Air Station for the National Aviation Facilities Experimental Center (NAFEC), which was commissioned in August of 1958 and absorbed into the newly formed Federal Aviation Agency, an independent predecessor of the Federal Aviation Administration, now in the Department of Transportation.

NAFEC today is a facility with a capability that is unique around the world. It includes a modern airfield with standard and developmental installations; a fleet of aircraft; range instrumentation, navigation, and electronic test bed facilities; air traffic control laboratories and simulators; a variety of computers; and other special and general purpose facilities. It represents a microcosm of the world's aircraft fleet and traffic control system of all levels and ages.

The situation that prevailed in 1957 prompting those actions then prevails today for very much the same reasons and an upgraded NAFEC is critical to resolve that situation.

The reference to "upgrading" in no way is intended to downgrade the worldwide reputation and positive impact on aviation that NAFEC developments have accomplished. The full advantage of the resources

- 20 -

of NAFEC have not nearly been realized for many reasons including some "ageing" and dilution of capability. Attaining maximum effectiveness of such a unique tool does not require legislation, but simply is a problem of management and resources appropriate to the national goals. NAFEC shares with the Transportation Systems Center (TSC) in Cambridge, Massachusetts the FAA responsibility to develop new technology and equipment to keep pace with civil and military aviation air traffic requirements.

In 1969 the NASA elected to phase out its Electronic Research Center in Cambridge as excessive to its needs. For reasons beyond the scope of this discussion the Department of Transportation elected to take over the facility and personnel for the purpose of pursuing projects related to transportation. Early on in 1971 58% of the TSC endeavor was devoted to civil aviation activity put there as a supporting subsidy by DOT. Over the last five years civil aviation R&D at TSC has diminished to about 20% of its total effort. The average has been 37% for the five years. The net result has served to dilute the resources and professional demands upon NAFEC, a miscalculation in good R&D management.

TSC has made available a high level of professional and technical skills. By virtue of that fact, R&D programs were diverted from NAFEC with the result that development of NAFEC professional depth suffered. The downgrading of NAFEC to primarily a test and evaluation activity amputates from FAA the critical requirement of a powerful research capability and scatters duplication of skills and equipment elsewhere. A rough approximation of the distribution of FAA Research, Engineering and Development resources (Airport and Airway Trust Fund) is shown in the figure (p. 22).

The core capability of FAA R&D rests in NAFEC, being assigned about 40% of the working resources. Of this NAFEC places about one fifth out to outside contractors. About 11% of FAA R&D funds go to TSC where more than half of that goes to outside contractors. A conceptual idea may have to find its torturous way through six layers of administration to go from headquarters to TSC, to a vendor, to TSC, to headquarters, to NAFEC finally, for test and evaluation, with loss of continuity and objectivity all along the line. Complex systems devel-

opment does not lend easily to such management.

The second figure (p. 22) illustrates the duplication of areas of interest and resources. The preponderance of capability resides in the facilities at NAFEC.

Now that TSC no longer relies on aeronautical research for survival, it may be timely to exert decisive management to attain the fullest benefits of the FAA inhouse capability. To make a truly integrated contributor out of its research establishment FAA should:

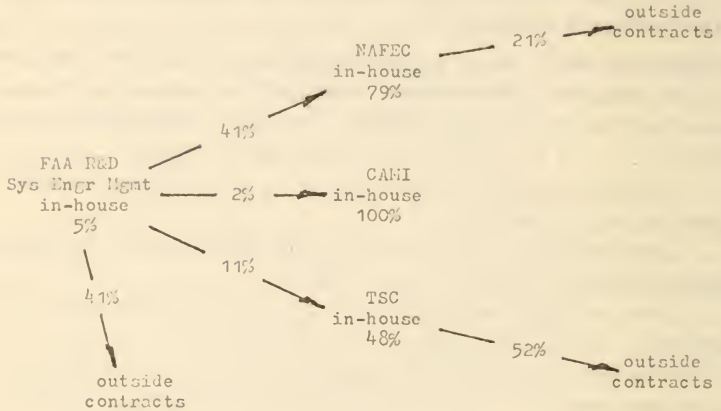
- * Transfer the bulk of TSC aeronautical R&D activity to NAFEC to strengthen its role and to
- * attract high levels of professional skills to fill the void in degree levels and conceptual depth, and to
- * provide fuller coordination of resources to bring new and novel developments to practical application. Further
- * the full assembly of participating contractors and other FAA tenant functions would serve to vitalize ideas, competition and productivity.

All of the above follow the guidelines of good effective management of the research and development of complex new systems as compared to the scintered management now in effect. The results would be a laboratory where all ideas were subjected to scientific, technical, and experimental judgements; measured for plan, system, and economic compatibility; developed to practical form; tested in the operational system; all with project continuity and without layers of burdensome administrative process.

The development of the managerial and technical strength at NAFEC to accomplish these ends is in the national interest.

- 22 -

**DISTRIBUTION OF FAA RESEARCH, ENGINEERING & DEVELOPMENT RESOURCES
(Airport and Airway Trust Fund)**



FAA R&D FACILITIES APPLICATIONS

	FAA Engineering and Development Program number																				
<u>NAFEC Facilities</u>	01	02	03	04	05	06	07	08	12	13	14	15	16	17	18	20	21	11			
Aircraft	X	X	X	X	X	X	X	X	X	X	X	X		X	X						
Airfield	X	X	X	X	X	X	X	X	X	X	X	X		X	X						
Range Instr/meas			X	X	X	X	X	X				X	X		X						
Simulation	X		X	X	X	X	X	X	X	X	X		X				X	X			
Surveillance Radar		X	X					X	X		X										
Com/Nav			X	X	X	X	X	X				X	X		X	X	X	X			
ATC Sys Lab			X							X		X									
Data Processing	X	X	X	X	X	X	X	X	X	X		X	X		X	X	X	X			
Air craft Safety									X						X	X					
Lab Service	All program areas as required.																				
<u>Transportation</u>																					
<u>Systems</u>																					
<u>Center</u>	X		X				X	X		X		X		X			X	X			

Legend: 01 System 08 Arprt/Arstd 15 Av Wx
 02 Padar 09 Arprt/Indstd 16 Technology
 03 ATCRBS 10 Oceanic 17 Satellites
 04 Navigation 11 ATC Com Cntr 18 A/C Safety
 05 ASA 12 Arprt Cntr 19 Av Med
 06 Communications 13 FCS 20 Env Prctn
 07 Apprch & Lndng 14 Trm/Twr 21 Support

SECTION I

FAA RESEARCH, ENGINEERING AND DEVELOPMENT

SUMMARY AND CONCLUSIONS

SUMMARY AND CONCLUSIONS

It sometimes appears that we fall into the habit of attacking the wrong end of our problems. In air transportation we have the unique situation of a very popular and high demand business that finds itself in serious financial trouble. Our current obsession seems to be with how to continue to finance an industry with a multitude of, as yet, unsolved internal production problems. It is not at all clear that just more money will effect any lasting change for the better. A hard look at the production problems is in order. The major controllable cost in air transportation is that of flight operations. Air traffic management is one primary contributor to the productivity of flight operations.

Efficiency and unconstrained flexibility of the air traffic management system is a worthwhile and probably attainable goal. A healthy and prosperous air transportation system can derive from eliminating low productivity and waste in the operational system. Eliminating the inefficiencies in ATC alone would result in a substantial improvement in the air carrier profit picture. Given this, it naturally follows that the aircraft industry then would regain a tenable financial posture from the domestic market. Then, we would again have the basis to compete in the world aircraft market with products based on quality, technology and price without contrived international arrangements. How do we fix the air traffic system? That question really means: how does FAA fix the air traffic system?

First, it is more than coincidence that the most energetic progress in commercial aviation has occurred during short periods when aviation was permitted to speak with its own voice. To borrow successful experience from the past, an initial recommendation quotes President Eisenhower:

"An independent Aviation Agency should be established into which are consolidated all the essential management functions necessary to support the common needs of the military and civil aviation of the United States."

We are again faced with the choice between textbook governmental structure and what will really work on the American scene. In any event, whether this initial recommendation flies or not, there are other pertinent recommendations that precipitate from this section of the review of Aeronautical Research and Development:

- 1) Establish an Air Traffic Management Modernization Board to completely overhaul and redesign the air traffic system concept to 21st century standards and provide a transition implementation plan.
- 2) Establish the mechanics to periodically review and reaffirm the efficacy and progress of the resulting programs.
- 3) Direct future design of ATC systems to distribute responsibility between controllers and pilots according to defined roles.
- 4) Aim at full airborne tactical capability and an air/ground cooperative system utilizing an accurate common navigation system.
- 5) Design the ATC and route system to attract redistribution of concentrated hub carrier traffic to re-balance distorted general aviation growth and to catch up with growing regional demands.
- 6) Overhaul and substantially strengthen NAFEC or equivalent FAA inhouse capability to enable FAA to keep abreast of advancing requirements.
- 7) Upon determination of an adequate plan assure adequate assignment of continuing resources and high level attention to assure success.

General aviation aircraft are to the air lines what automobiles are to bus and rail. The distorted growth of general aviation arises from neglect of our short haul regional air transport system, much as automobile traffic, in part at least, grew out of the shortcomings of bus and rail service. Continued indifference to regional short haul air transport may very well invite a chaos in general aviation similar to the automobile problems.

APPENDIX I SECTION I

Determining Costs of ATC System Delays

The operational block hours that are nonproductive because of ATC system delays can be determined at least three ways:

1. Compare performance of mid-day flights to that of middle of the night flights. The block time difference is in the day-time traffic delays.
2. Compare all flight's 50% block time on time performance with best level experience. The differences are in ATC system delays.
3. Compare each flight's performance to computer flight plan based upon best empirical data input. The difference is in the ATC system delays.

All three methods yield very similar results in terms of total accumulated ATC system delay times. None of the three methods account for the 250 ft limit under 10,000 feet altitude as a system delay.

Costs or losses attributable to nonproductive flying arising from ATC system delays can be estimated over a wide range between two boundaries:

1. Nonproductive flying costs can be assumed to be the direct out of pocket expense for the nonproductive hours flown. These costs represent the lower boundry.
2. The revenue that the nonproductive flying would generate if it were productive represents the upper boundry as loss. Regaining those losses would be the same as adding equivalent productive aircraft to the fleet at no expense.

In an airline system, that is generally sized and budgeted based upon annual block hours, the latter (2) probably is closer to the real cost to the air line in terms of the loss of productivity of the whole air line structure.

Figure A-I-I illustrates the spread of costs, because of ATC system delays, over the last several years. The several points identified as "BAL" are from hard data costed both of the ways above. The BAL cost and loss dollars are shown on the left hand scale.

Eastern Air Lines represents a middle haul airline between the longer haul trunks and the shorter haul trunks and locals. Eastern flies into over 100 airports from major hubs to "whistle stops". Eastern flies about 11% of scheduled airline revenue flying.

If Eastern is assumed to be a fair sample of the U.S. scheduled air line system, then the U.S. system delay costs would be about nine times those of Eastern. Therefore, the right hand scale represents an approximation of the U.S. air line system's ATC system delay cost and loss method zone by extrapolation of Eastern's experience.

The specific points illustrated () were calculated as follows:

- (1) Refer to (1), Figure A-I-I. The 1967 to 1969 delay hours were based upon comparing day time block times to late night freighters which were then prorated across the system (calculation method #1). Flight operations expense, based upon the delay hours, amounted to \$137,000,000 over the three years.
- (2) The scheduled average flight times of the winter of 1972-73 for 913 daily flights were sampled. Figure A-I-II represents the envelope of the scheduled times, based upon 50% ontime performance, of the 913 flights. The bottom boundry represents the best obtainable block time by experience. The difference between each flight's scheduled time and the lower boundry represents accumulated delays from circuitry, routine ATC, preferred approach and departure routes, etc., in short: ATC system delays (calculation method #2).

913 flights, average delay = 6.4 minutes per flight
= 35,571 hours per year

In 1972 one block hour generated an average of \$1400 of revenue, therefore the 913 flight's nonproductive flying represents a revenue loss of about \$50,000,000 a year (2).

- (3) Extrapolating (2) to the 1450 flights per day on the Eastern system in 1972 indicates a yearly revenue loss of \$79,000,000.
- (4) If only direct out of pocket expenses are charged, the prorated flight/taxi hourly costs are \$477 for 56,453 hours amounting to some \$27,000,000 annually
- (5) For 1975 Eastern reported (calculation method #3):

Airborne net delays, 1410 flights = 3.45 minutes per flight
= 29,579 hours per year

@ direct costs of \$902.68 per hour

Airborne delay annual costs = \$26,706,000.

Taxi net delays, 1410 flights = 3.61 minutes per flight
= 30,979 hours per year

Direct costs of \$459.82 per hour

Taxi delay annual costs = \$14,245,000.

The total annual direct costs are = \$40,951,000.

These nonproductive hours are, in addition, equal to 19 equivalent aircraft in the fleet.

(6) Were those 60,558 annual nonproductive block hours of (5) to produce revenue:

1975 revenue generated per block hour, prorated to all productive flying, is approximately \$2000 per hour, therefore:

The annual revenue loss = \$121,116,000.

(7) The FAA handled about 5,000,000 air carrier flights in 1975. If the Eastern experience of 7 minutes ATC system delays per flight is a fair representation, then the U.S. air carrier system experienced a nonproductive flying cost of \$397,448,000 based upon a prorated \$681 per block hour direct costs.

(8) Revenue not generated, based upon the \$2000 per block hour figure, then amounts to a \$1,167,000,000 annual loss for the U.S. carriers.

None of the above calculations include the delay costs of the 250 kt restrictions below 10,000 feet (FAR 91.70). As an ATC system delay this can add 2 to 3 minutes per flight more to these cost and loss estimates. This amounts to an additional 20 to 40% to the figures above and those of Figure A-I-1.

Therefore, based upon this line of reasoning, the scheduled carriers alone may currently approach costs of a billion dollars a year wholly due to the ATC system. Further, more than 5,000,000 general aviation and military IFR aircraft share a similar annual nonproductive circumstance as an additional charge to U.S. air transport.

Data Sources

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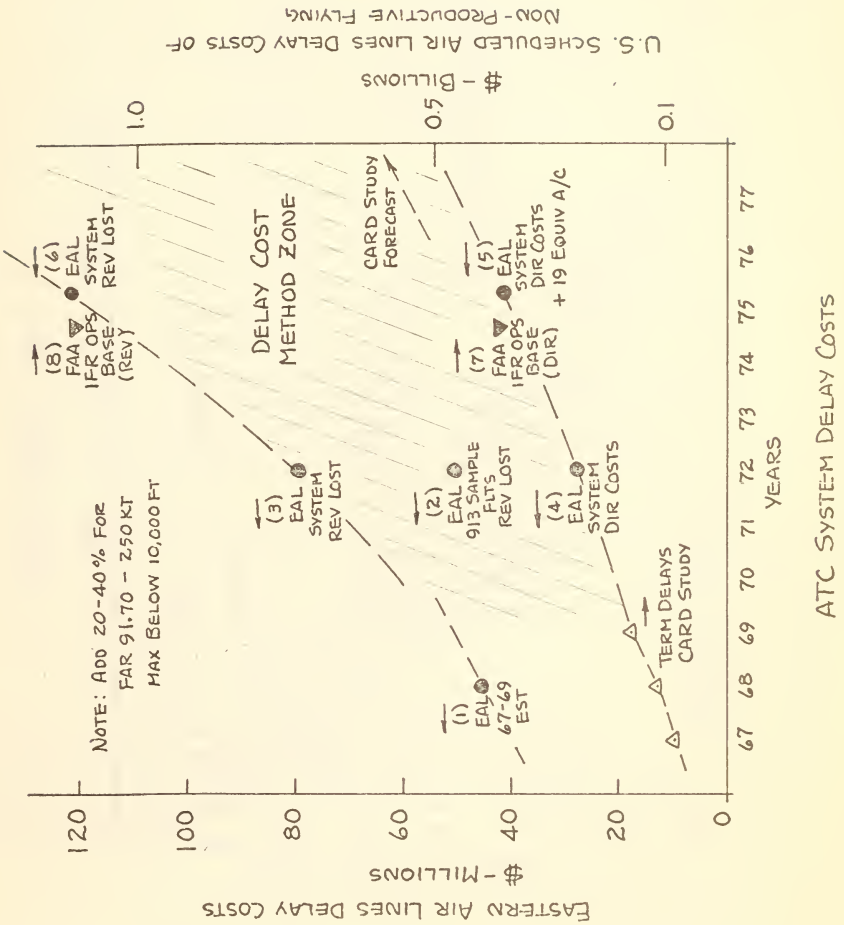


FIGURE A-I-1

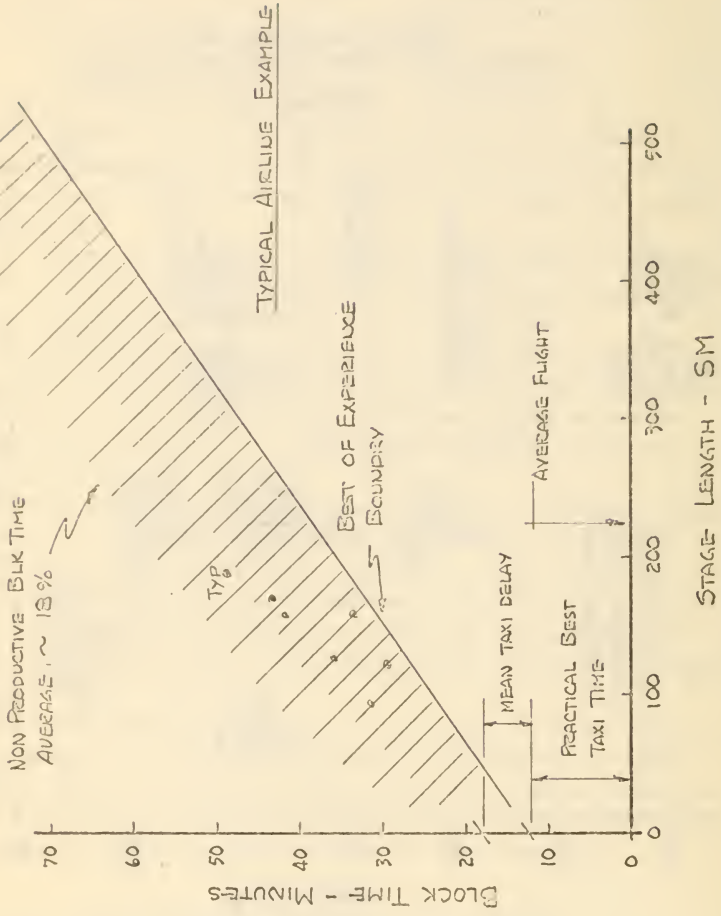


FIGURE A-I-II

APPENDIX II SECTION I

Block Time vs Aircraft Performance

The block time performance of any carrier fleet is the major measure of productivity. The number of minutes of ATC delay per flight increases with range, or with the time that the aircraft is in the system. The proportional effects at short range, under 500 miles, where the demand is highest, are very large because of the relatively short time at cruise speed and altitude and the high percentage of time spent in terminal areas.

Figure A-II-I illustrates the average block speed vs range of current experience. The spread amongst thousands of domestic carrier flights is over 100 mph out to beyond 600 miles range. The average flight below 600 miles loses 50 mph to ATC delays inherent in the system. In the congested corridors the impact is greater, nearer to 100 mph performance penalty on the average.

The increased performance that came with the jet era was not wholly realized. While cruise speeds increased about 66%, the block speed in the congested corridors increased 25 to 30%. The average domestic carrier flight realized about 45% increase in block speed at around 500 miles range.

The proportionately high time spent in terminal area operations, with delays discussed above, plus the 250 knot restriction to 10,000 ft (FAR 91.70) severely penalizes high performance aircraft in the high demand short haul market. The accumulated delays amount to between 15 to 20% of the total block hours.

Data Sources

Short Haul in Perspective, Crossfield, EAL, 1973

STOL Demonstration - Technical Report, Crossfield, EAL, 1969

Short Haul Air Transportation, Boeing Commercial Airplane Co., 1973

Official Airline Guide

EAL Flight Operations Manual, Vol. I

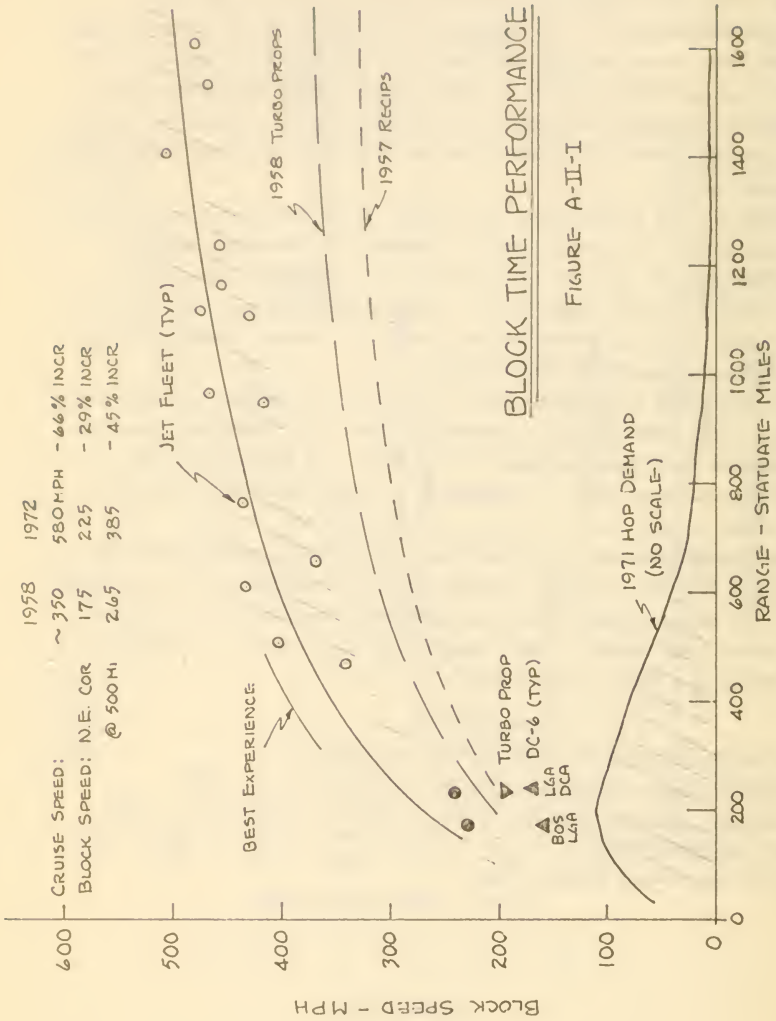


FIGURE A-II-I

NATIONAL
CIVIL AVIATION AND AERONAUTICAL
RESEARCH AND DEVELOPMENT
A LIMITED REVIEW

SECTION II
NASA AERONAUTICS RESEARCH AND TECHNOLOGY

FORWARD

This section of the review of Civil Aviation and Aeronautical R&D deals with the criteria that guide NASA's design of their research programs.

A well earned worldwide reputation for technical and scientific depth and integrity permits NASA to play a unique role of credibility and wisdom. In the technical and scientific world this is undoubtedly justified. That very role, though, may sometimes form an insulation from the hard and pragmatic demands of the national air transportation system for R&D.

NASA faces a herculean task to sort out clear signals for definitive needs in the absence of clear policy guidance. Research is at its best when focused upon objectives contained in national goals. Those objectives must be defined by operational requirements. In the absence of national goals and objectives NASA has difficulty in achieving a planned consistent program from only fashionable inputs. Because of this, it is not irreverent to surmise that some research requirements are contrived. Criteria for the appropriation of research priorities are, therefore, arguable.

This critique is not all inclusive by any standard. It does explore the institutional environment. It suggests that some contradictions may exist within the NASA program that should be reconciled. Some examples are used to indicate some absent or misdirected response to national requirements. The endeavor is to constructively contribute to improved productivity of the R&D activity and to provoke development of a better definition of the NASA role in the changing national picture.

CONTENTS

FORWARD	
GOVERNMENT SPONSORED AERONAUTICAL R&D	1
AERONAUTICAL R&D IN THE 1976 FRAME	1
The R&D Program Process	3
THE SCAN OF THIS REPORT	4
THE RELEVANCE OF NASA AERONAUTICAL R&D	7
The SST Holding Pattern	7
Aeronautical R&D Productivity	7
Whose Short Haul ?	10
And, Engine Technology	11
Jack of All Trades	12
Helicopter "Facts"	12
WHO GUARDS THE INTERNATIONAL SCENE ?	13
A FIRST ORDER CONCLUSION	14

GOVERNMENT SPONSERED AERONAUTICAL R&D

Government sponsored aeronautical R&D cannot afford the luxury of being "for knowledge sake". The competition for available funds and skills allows little leisurely and scholarly aeronautical R&D in the government sector. The demands of the industry now and in the future are twofold: 1) to get our money's worth from R&D to maintain a healthy air transport and manufacturing industry and, 2) to invest for a maximum advantage for a probable future.

It would be futile to attempt an intelligent assessment without, at least, a best guess of the future picture that we are shooting for. The assumption here is that the earlier thesis of future industry and population migration from the super cities is valid (see section I). For any evaluation of this nature, the institutional framework and characteristics have a heavy bearing upon sensible and objective conclusions. Now we arrived at our present position, and the lessons gained, influence how we go from here.

AERONAUTICAL R&D IN THE 1976 FRAME

Civil aviation aeronautical R&D ("Aeronautical R&D") can be taken as a discussion subject in itself as different from air transportation operational R&D ("Civil Aviation R&D") discussed in Section I. The latter finds itself in the province of DOT/FAA. Aeronautical R&D in the physical technologies falls upon NASA and the industry, with an important fall out from the Military. The industrial R&D is very difficult to measure and currently is severely cut back for short term economic reasons. This should be of vital concern in the bigger picture than discussed here. However, government sponsored "Aeronautical R&D" only is addressed in this section.

After many fitful starts, aviation came into economic respectability and with full government recognition in the national scheme about 1938. The Civil Aeronautics Act of 1938 and the war set the stage for twenty years of national fascination with aviation. Aeronautical R&D flowered and, as a result, carried the country into worldwide technical and industrial leadership. We are still enjoying the momentum of those time as our industry has been spending the technology that was stored then against the future. The excruciating question

- 2 -

is whether we will sustain that momentum or are we losing it ? Have we been spending the technology account faster than we have been making additional deposits against the future ? The answer is: yes, we probably have been.

Beginning in 1958, several circumstances have had a profound effect upon the direction and policy of aeronautical R&D after the explosion of the 1950's. The creation of FAA gave aviation a powerful and effective platform with a positive impact across the spectrum. Conversely, the creation of NASA represented a negative impact by diversion of major interest and investment to space. The McNamara era and implementation of the Department of Transportation Act put down aviation severely. A flurry of consciousness in the late 60's started to rebalance things but ran athwart the growing social awareness movement that diverted almost all attention to the environmental issues. Thus, the combined toll imposed upon civil aviation was high. The common purpose and direction of aeronautical R&D eroded and its focus was virtually lost. The transport system began to bog down, the previously close association of military and civil hardware development disappeared, the FAA lost its vigor in DOT, and administration of aviation affairs reverted to Congress by forfeit.

The creation of NASA in 1958 inadvertently caused the loss of a very important policy command and control element that had been the device that kept national aeronautical R&D focused on operational requirements and in perspective. The old National Advisory Committee for Aeronautics of the Hunsaker and Doolittle mold served pretty well to integrate wide and parochial interests into national R&D policy. With its disappearance there followed the gradual disappearance of guidance at the White House and at executive level in the government. What once had been an organized means of determining national priorities in aeronautical research fell to the responsibility of the Congress alone.

The NASA concept changed the detached role of the NACA to one which was competitive with the Military for programs, skills, dedicated manufacturers, and appropriations for system procurements. This self serving role, now created two separate and powerful factions of government and industry, each with their own overlapping claims on the

- 3 -

national technological resources: the NASA and the Military. Civil aviation came out a bad third compounded by being submerged in a disinterested DOT. One has to raise the question of whether the drifting apart of the NASA, Military, and FAA common interests has been related to this loss of cohesive leadership. The Research and Technology Advisory Council of the NASA Office of Aeronautical and Space Technology has made a valiant effort to fill the void. The fact that outside pressures were needed to regain more than token attention to aeronautics gauges the effect.

The R&D Program Process

The civil aviation transportation requirements under government purview are translated into active programs through a very complex maze that has grown as national priorities have changed through the years. There are a number of academies, foundations, and councils that advise on priorities and needs for the future. Their several inputs follow tortured and varied paths to implementation:

CONGRESSIONAL COMMITTEES INVOLVED IN TRANSPORTATION

7 House Committees, 20 subcommittees

5 Senate Committees, 13 subcommittees

Civil Air Transport

5 House Committees, 10 subcommittees

5 Senate Committees, 7 subcommittees

FEDERAL AGENCIES INVOLVED IN TRANSPORTATION

33 Federal Government agencies

8 are part of DOT

7 provide financial assistance

22 provide facilities

5 are involved in economic regulation

12 invest directly in R&D

7 are involved in safety

Civil Air Transport

14 Federal Government Agencies

2 are part of DOT

3 provide financial assistance

12 are involved in facilities and services

3 are involved in economic regulation

- 4 -

4 invest in, and direct R&D

4 are involved in safety

A rough approximation of the distribution of the civil air transport national product appears:

The total U.S. expenditures on civil air transport exceed twenty billion dollars (\$20B).

Private expenditures	80%
Total government expenditures	20%
State and local (incl rev sharing)	7%
Federal	13%
DOT and NASA (incl user tax)	11%
Other	2%
Identified as R&D	3%
Military civil fall out	1 1/2%
FAA	1/2%
NASA	1 %

Such a wide distribution of authority and resources indicates the need for some form of authoritative clearing house. It will be a recommendation of this report that something of an executive level national aviation body be given the authority to pull the requirements of these 14 agencies, the industry, and the users together to present a common sense, integrated case to those Congressional committees.

THE SCAN OF THIS REPORT

This section of the review endeavors to look at the 1% of the civil air transport product that is in the NASA house. Are NASA aeronautical R&D programs assembled to best meet the needs of the future? To avoid detailed involvement, specific examples are drawn against the prognosis of the future in Section I only as illustration. But, we also have another yardstick.

At the direction of the Senate Committee on Aeronautics and Space Sciences, a joint NASA/DOT Civil Aviation Research and Development (CARD) Policy Study Group was formed. They issued a study of the subject in depth in 1971. Coordination with all aviation interests, government and private, resulted in an "outstanding" report that provided a significant contribution to the level of understanding of the problems

- 5 -

and the guidelines for action. A high level CARD Review Group was appointed and a CARD Policy Implementation Group was formed to develop an Implementation Plan. The Senate also directed that the activity be extended on a continuing basis. This was not done and the CARD Study impact diminished to insignificance.

The Implementation Plan addressed in detail the scheduling and resources judged necessary to accomplish the CARD Study recommendations. It addressed the significant needs for:

- Solution of the aircraft noise and pollution problem.
- Expansion of air system capacity and relief of congestion.
- Improvement of the effectiveness of short haul air transportation.
- Continuation of the United States leadership in civil aviation through the maintenance of a strong technology base.

Five years later, it is hard to fault the validity and urgency of those recommendations. If totally updated today, the CARD Study conclusions would be changed little except to pull out, as a major recommendation, the need for additional emphasis on energy conservation ("operating efficiency" by past nomenclature).

The CARD study has been criticized for not addressing the economic picture. The criticism is somewhat unfounded since implicit in the entire study is that failure to step up to the future spells economic disaster. It can be argued that not addressing the needed actions in time has already depressed the economic picture.

If one attaches any validity to the CARD Study and updated recommendations, we are already facing crisis in the future. Lest that seems an exaggeration, let's look, for example, at the figure on page 6 (fig 1). It illustrates the summary conclusions of the CARD Implementation Plan as to the necessary resources to accomplish CARD recommendations. The current application of resources is compared. The conclusion must be that the CARD Implementation plan is completely invalid, or we have a new problem as to how we eventually pay the piper. Is such a gross shortfall in investment in future prosperity good economics? With air transport as the flourishing and expanding national transportation mode, history would indicate that as goes aviation, so goes the nation. Bold and visionary government action is needed.

- 6 -

DOT AND NASA CIVIL AVIATION R&D

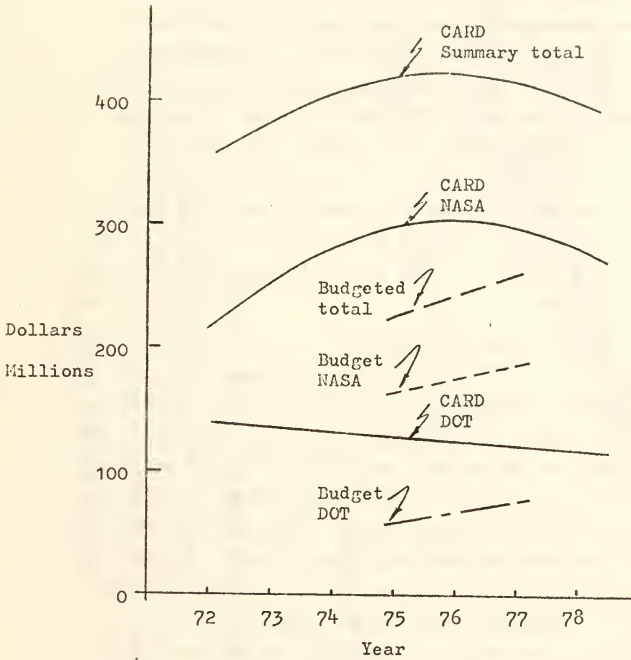


FIGURE 1

In view of the foregoing assessment, any attempted review of NASA R&D programs must of necessity deal with emphasis rather than adequacy. Do we in fact get the maximum return from a wide variety of limited programs, or should we glean more from a limited number of amplified programs? It is beyond the intent of this review to evaluate details of R&D programs. The intent is to grasp for the criteria against which we can gauge best performance in relation to requirements.

- 7 -

THE RELEVANCE OF THE NASA AERONAUTICAL R&D

The facts of the necessity to sustain a high level of new technology for the international marketplace are clearly illustrated in the figure on page 8 (fig 2), borrowed from NASA. Any attenuation of a fully adequate investment in new technology clearly compromises the United States' position in the world marketplace up to the tune of tens of billions of dollars. As if the picture were not grim enough, it only tells part of the story. In some areas the lack of competitive technology not only denies us access to the world market, but may, additionally, force us to buy on the world market ("U.S. Imports", fig 2, added by the author). The helicopter industry, for one is sliding in this direction.

The SST Holding Pattern

For another example, the SST can be a very good case in point. The scepticism in the past about supersonic flight itself, like the scepticism in the past about the productivity of jet propulsion, must be too fresh in our minds to not harbor deep concern for the national scepticism about the SST. Our day for day falling behind in hard design data for SST construction is unacceptable. The immediacy of widespread trans-Siberian and trans-oceanic supersonic travel, the avowed intent of our competitors, bodes ill for our ability to remain aloof from such a potentially major manufacturing and transportation arena. That is just the start. It is incumbent upon NASA to be prepared to catch up rapidly when the nation awakes to the facts of life. Our present national posture notwithstanding, supersonic travel is inevitable. And it will not be a penny ante game.

Thus, a recommendation of this report is to give our preparedness for the SST the highest priority.

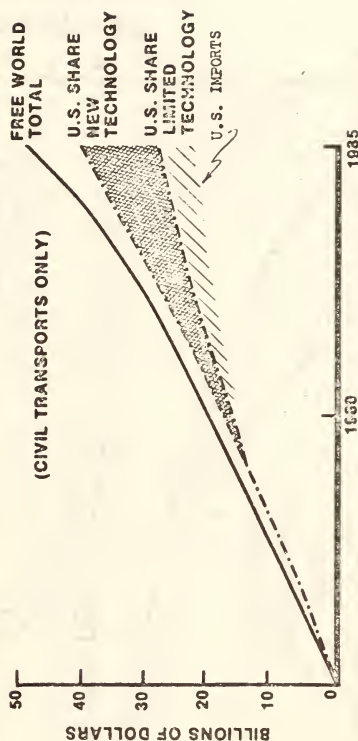
Aeronautical R&D Productivity

A second point on addressing broad R&D criteria can be drawn from the illustration on page 9 (fig 3), also borrowed from NASA. Here we see a very rapid increase in the lag from R&D to productivity out to 1990. Does this mean that there is no immediate need? Or does this come from a failure to respond to R&D requirements "with a view to their practical solution"? In the 1950 era NACA was hard put to stay ahead of the industry, and lags were sometimes almost negative. Space

AVIATION FACTS

- CIVIL AIRCRAFT • 78% TRANSPORTS ARE U. S. BUILT
- \$5 BILLION EXPORTS IN 1975 (Aircraft, engines, parts)
- FOREIGN COMPETITION INCREASING RAPIDLY
- HELICOPTERS • U. S. ALREADY LOSING GROUND

MARKET PROJECTIONS



• NEW TECHNOLOGY NEEDED TO CAPTURE NEXT
GENERATION AIRCRAFT SALES

FIGURE 2

AVIATION GROWTH 1940-2000

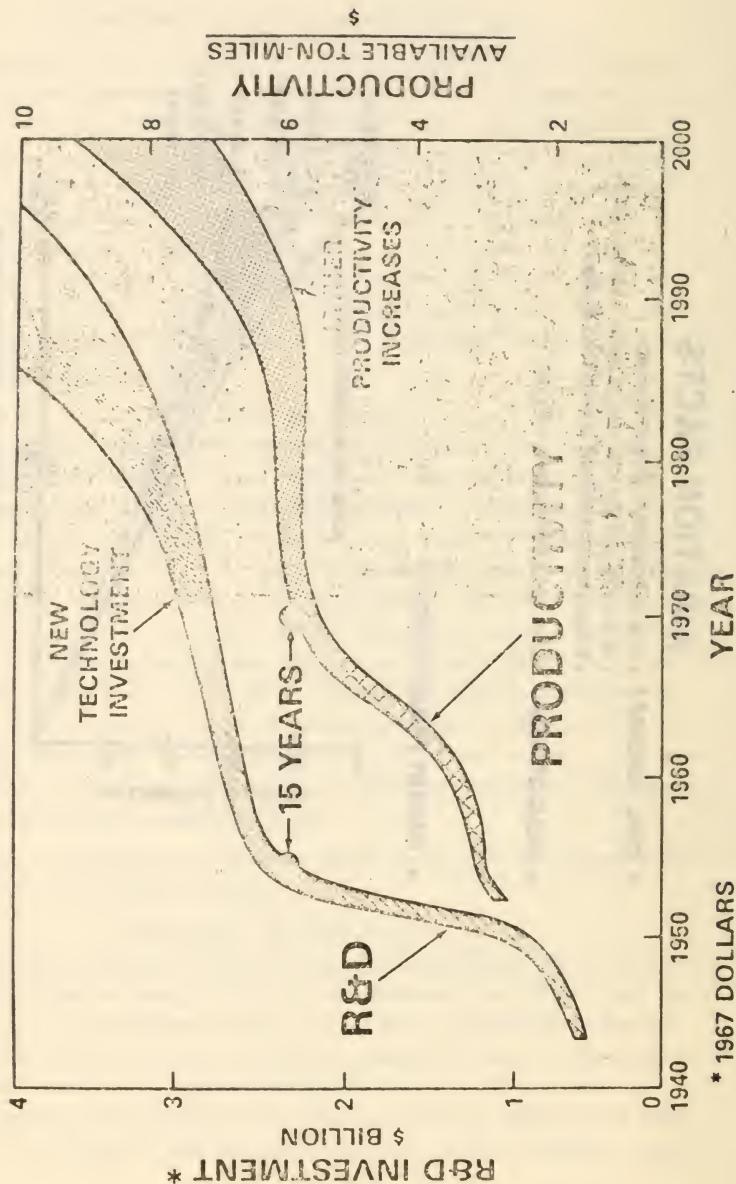


Figure 3

- 10 -

R&D productivity today is in a similar circumstance. So, the 15 to 20 year lag suggests that: 1) we have no immediate problems or, 2) that NASA is not responding with pertinent applicable R&D. With no inclination to forfeit the long term, this report suggests that the near term is not being recognized and adequately served.

Whose Short Haul

A case in point here could be for short haul requirements. At least three regional air lines and two trunks have for several years decried the urgent need for a short haul concept to, 1) replace the aging propeller fleet and, 2) economically meet the onrushing growth in demand. Meetings, conferences, symposia, coordinated specifications, and studies surrounded the problem. The vague form of STOL became identified with the effort. The carriers' requirements defined a short field airplane with airborne enroute and terminal guidance capability--these, to grossly expand the utilization of unused runways, airports, and terminal and enroute airspace.

NASA took the problem and ran with it into blue sky technology. They defined STOL as a 1500 to 2000 foot runway requirement to be accomplished with expensive powered lift technology. The carriers had long since decided they were comfortable with 3000 to 3500 foot runway capability at much less cost. The NASA development aimed at "downtown", "rooftop", etc airports. It takes little clairvoyance to recognize this as a pipe dream. There is no concurrent effort devoted to onboard guidance systems to get out of the main traffic stream. Without this, STOL is rendered nearly useless, and the carrier RTOL spec is compromised. In short, NASA did not respond to the real need in favor of a contrived one. In the end, the carriers were, and are, stuck for some time with their aging and unmatched fleet and an unanswered requirement. The carriers had no choice but to withdraw from a concept they couldn't use. The manufacturers, on the other hand, cannot meet the carriers' specifications and economics without new systems technology.

Referring to the summary FY '77 NASA R&D proposal (table 1, p. 11), twenty three of the twenty seven line items are applicable to the shorthaul aircraft requirements, 94% of the effort is related. The glaring omission is the integration of this technology into a systems technology for short haul aircraft applications.

- 11 -

NASA FY 77 AERONAUTICAL RESEARCH AND TECHNOLOGY

RESEARCH AND TECHNOLOGY BASE		FY 77
		Level
1. Materials research and technology		3.4%
2. Structures research and technology		3.5
3. Propuls envr impact min res and tech		6.5
4. Propulsion components research and technology		5.3
5. Air breathing engine research and technology		4.1
6. Avionics research technology		2.4
7. Fluid and flight dyn research and technology		6.1
8. Low speed veh aerodyn and flight dyn res and tech		6.5
9. High speed veh aerodyn and flight dyn res and tech		4.7
10. Aircraft ops and safety research technology		2.2
11. Aeronautical human, vehicle res and tech		2.8
		(47.5)
12. Systems Studies		1.6%
SYSTEMS TECHNOLOGY PROGRAMS		
13. Materials and structures systems technology		3.4%
14. Propulsion systems technology		9.5
15. Avionics systems technology		1.5
16. Aerodynamic vehicle systems technology		4.1
17. Aircraft operating systems technology		4.5
18. Aeronautical human-vehicle systems technology		0.3
19. Advanced civil aircraft systems technology		8.7
20. Military aircraft systems technology		0.2
		(32.2)
Experimental Programs		
21. Composite primary aircraft structures		8.5%
22. Quiet, clean, short haul experimental engine		1.7
23. Quiet propulsive lift technology		0.9
24. Supersonic cruise aircraft research		4.2
25. Tilt rotor research aircraft		0.4
26. Rotor systems research aircraft		0.2
27. Highly maneuverable aircraft technology		2.9
		(18.8)
		100.0%

Table 1

Thus, the long term concepts prevailed over urgent short term requirements.

And, Engine Technology

To follow in a similar vein: whether it be STOL, RTOL, or any fixed wing short haul airplane, it will spend most of its operational life in the arrival and departure mode. Very promising here is the variable pitch fan, very high by-pass engine technology. The flexibility to match thrust or reversal to maneuvering requirements, the gains in efficiency and thrust promised, the quieting available, and the efficiencies of optimized spool speeds, are all very attractive potentials that we really

- 12 -

know little about. The NASA variable pitch fan effort is buried in the QCSEE engine with a 1990 operational date. If we accept the report thesis that the future holds a dispersal of business and population throughout the country, then it is even more imperative that all promising short haul systems R&D be pursued with urgency.

Jack of All Trades

The above argument poses the question of where is the point to which NASA must be charged to bring problems to a practical solution. Of course, one definition is that point where the user can pick up R&D results for design or operational application. But further, it also may be the point beyond which NASA can no longer claim unique capability and is wasting critical resources. Here, an illustrative point, is their deep involvement and investment in noise reduction approach techniques. This is a procedural and operational area that is none of NASA's business. The FAA should be pursuing these techniques with all diligence. NASA has little or no expertise in all of the ramifications that could ricochet around the very complex system of air traffic management.

If the several techniques: two segment, reduced flaps, delayed flaps, etc., have merit, and it appears that they do, they must be evaluated as an integrated design element of the whole approach system. Proposed techniques can be good for Dulles and bad for Boston and Los Angeles. A wide variety of safety aspects must be considered before time and resources are wasted. The single question of being able to manage a mixed bag of approaches at a congested airport has not been addressed. Some simple criteria for safety, learned the hard way, has been ignored. In short, the basics of good operational experiment design are missing. This form of operations research should be designed and accomplished at NAFEC by experts in the field.

This seeming contradiction is not to discourage NASA from doing practical research but to discourage research that other agencies can do, are in fact charged with doing, and can do better.

Helicopter "Facts"

NASA's "Aviation Facts" (figure 2) declares: "Helicopters--U.S. is already losing ground" in the international market. The U.S. is

also importing an increasing number of helicopters and amounts of technology. The Aeronautical Research Program (table 1) and supporting documentation does not clearly define the level of VTOL effort. This is just to make a point that such a critical national interest should be systematized, scheduled, and made a maximum priority line item. But, there are also special problems.

Helicopters and other powered lift machines are different and unique compared to fixed wing aircraft in an important R&D sense. There is no way currently available to do design development of commercial vertical lift and compound vehicles other than by trial and failure techniques.

- Because of the large effect of scale on very complex flow fields wind tunnel model techniques do not lend to full scale answers by a wide margin.
- The aerodynamic, dynamic, and air flow interactions of a complete vehicle are so complex as to not yield to analysis and test except in a full scale fully instrumented dynamic version to obtain sound data.
- Flight test is not an acceptable means of optimizing design except to accomplish very limited proof of concept. The inability to instrument for engineering verification precludes analysis in depth.
- The only way to systematically test and approach development of optimally designed helicopter type vehicles with any engineering rigor is to full scale test a complete elastically similar vehicle where full instrumentation and test repeatability are available.
- A quantum step can be made in vertical and compound lift technology if full scale wind tunnel testing is made available to the commercial industry.

It is a recommendation here that NASA review the 40 x 80 Wind Tunnel policy and make it available to commercial manufacturers for proprietary vehicles along the lines of the unitary plan. Some careful weighing of national interest must be accomplished.

- 14 -

WHO GUARDS THE INTERNATIONAL SCENE ?

With the present structure of the aeronautical endeavor in the United States the source of direction for the aeronautical effort is vague.

The NASA Outlook for Aeronautics draws attention to six foreign developments in aircraft and stops there. These six are competitive for world markets, are applications of current "best" applied technology, and have no U.S. counterparts. Five of the six are civil applications: Concorde, A300, DHC-7, ^{VFW614} and Dauphin plus the military Harrier. These unchallenged competitors span the spectrum of civil air transport requirements.

Nowhere do we see a concerted attack on this void in spite of the ramifications it may have on the U.S. market posture. A single most important question to be resolved is how to apply the acknowledged U.S. superiority in technology to prevent these inroads from foreign initiative.

How do we marshal U.S. forces to hold the line ? really to regain the line. It is suggested that until this question is effectively resolved, it is incumbent upon NASA to take a much less casual position on close term research productivity.

- 15 -

A FIRST ORDER CONCLUSION

What is the foregoing all about ? It describes some examples of soft areas in the criteria for assignment of aeronautical R&D priorities. It claims gross insufficiency of the national effort. It claims that the institutional structure is truncated, without policy and leadership. It also recognizes that the easiest thing in the world to do is to criticize. It would be a brazen conceit to expect this review, at this stage, to go beyond a philosophical context. However, one specific factor that cannot be ignored is the need for a keystone.

There is no forum where civil aviation operational and technological R&D can be forged into a well designed system that best fits the scheme of the nation. This deficiency is not limited to R&D alone. It is a cross borne by the whole aviation community. For first things first: to assemble a well designed national aviation program, including R&D, there is the first and foremost requirement for an authoritative executive level body with national visibility, aviation responsibility, vision, foresight, and courage.

REVIEW OF NATIONAL AVIATION
R&D FACILITIES AND PROGRAMS

A REVIEW OF NASA WIND TUNNEL RESOURCES

Submitted to

The Honorable Dale Milford, Chairman
Aviation and Transportation R&D Subcommittee
House Committee for Science and technology

by

A. Scott Crossfield

June 18, 1976

CONTENTS

A REVIEW OF NASA WIND TUNNEL RESOURCES	1
NASA Wind Tunnel Inventory	1
NASA Wind Tunnel Capability	2
Development Tunnel Limitations	3
Full Scale Engine Installation Testing	3
Full Scale Vehicle Testing	4
A Question of National Policy	5
A Question of NASA Policy	5
Balanced R&D	6
SUMMARY AND CONCLUSIONS	12
FIGURES	
Figure I, NASA Wind Tunnel Inventory	8
Figure II, Wind Tunnel Capability Growth	9
Figure III, Continuous Flow Wind Tunnels	10
Figure IV, Intermittent Wind Tunnels	11
APPENDIX	13

A REVIEW OF NASA WIND TUNNEL RESOURCES

The Chairman of the House Subcommittee for Aviation and Transportation Research has initiated a "Review of National Aviation R&D Facilities and Programs". One of the Review objectives is to "Identify NASA and FAA Aviation R&D facilities and review the utilization of such facilities".

In response to a request from the Chairman of the House Committee for Science and Technology the General Accounting Office has published GAO Report ST-65: "Acquisition and Utilization of Wind Tunnels by the National Aeronautics and Space Agency". A copy of the "Digest" of that report is attached as the Appendix.

This report concerns a first summary analysis of the NASA Wind Tunnel facilities inventory and touches a few points of interest. NASA's annual aeronautical facilities budget requirements have averaged less than 10% of their annual facilities budget requirements for several years. Of that aeronautics facilities investment, very little stems from civil aviation requirements. Almost all advanced technology facilities arise from military and space aeronautical requirements. This same observation holds for research programs. Civil aviation new technology needs, except in very specific areas, lag military and space requirements 5-20 years. This is not very exciting and as a consequence the "development" phase of R&D, related to civil requirements, has suffered from indifference that is well documented elsewhere.

The burst of enthusiasm for aviation that started in the 1930's and carried through the 1950's was reflected in aeronautical research activity and the national investment in research tools. Wind tunnels have been a standard tool of aviation since the Wrights, and supersonic wind tunnels have been built by NACA since the 1920's. However, full capability and refinement into rigorous design tools for subsonic and supersonic investigations peaked in the 1950 era. The national investment in university, industry, and government wind tunnels reached maximum levels at that time also.

NASA Wind Tunnel Inventory

Seventy four wind tunnels are currently active in the NASA inventory, most have been built during and since WW II. Forty five facilities have been deactivated in that time. The investment at completion years for the 74 active wind tunnels is illustrated in figure I. The total initial costs

- 2 -

shown by the graph amount to \$215 million. An additional \$21 million for upgrading and modification (not plotted) brings the total investment in active facilities to \$296 million. Looking at the costs in five year increments indicates that a bulk of the funding was appropriated in the 1950's and the expenditures completed by 1965. In the last 10 years funding rates have been relatively low; distorted even more by inflation.

The question, of course, is: has this reduced rate of spending diminished our national capability?

NASA Wind Tunnel Capability

One primary baseline measurement for aerodynamic investigation is speed, or better, Mach number which represents the ratio of air speed to the speed of sound. Figure II graphs the operational start dates of a bulk of the active NASA wind tunnels, each of which has a specific Mach range or Mach number test capability. Continuous flow tunnels are represented by triangles and intermittent flow tunnels by circles. At higher Mach numbers, or for special purposes, continuous flow tunnel costs and energy requirements become very high. While test versatility and productivity are superior with continuous flow techniques, the intermittent tunnels serve very well, except where extended steady state conditions are required.

As figure II illustrates we were well covered up to Mach 4 by 1957. The difficult and important transonic region (approximately 0.9 to 1.1M) is a partial exception. New facilities that have come on line since 1957 are relatively limited or are special purpose facilities and are often space program oriented.

Through 1961 the progress of research airplane performance in actual flight (solid diamonds) illustrates that flight experience kept close on the heels of wind tunnel research and, in fact, briefly bypassed wind tunnel test capability. Military aircraft performance, also, followed very closely. Until about 1965 aircraft were flying at the higher speeds with considerable guesswork in design. This is still true to some extent as will be discussed below.

Commercial aircraft performance, as illustrated (solid circles), is pretty well covered by experimental aeronautics and thermal capability, as well as military and research airplane flight results. From this figure it can be surmised that research test facilities for commercial applications are adequate for many years to come except for specific considerations of Reynolds' number in the transonic region and up to Mach 4 in the range of 1-5 million per foot.

- 3 -

Development Tunnel Limitations

Reynolds' number, like Mach number, is a primary and base line design parameter. The flow characteristics of air, as with any fluid, vary significantly depending upon the actual distance it travels over a surface. Naturally that distance is greater over a full scale airplane wing than it is over a geometrically similar small wind tunnel model. Hence, "scale effect" (Reynolds' number) is important in extrapolating wind tunnel results to full scale design. Ideally test and flight Reynolds' number, along with Mach number, would be the same. There are many techniques devised to create similarity between test and flight Reynolds' numbers to obtain valid data. Except for full scale tunnels (at impossible costs) the many techniques are just barely adequate at best, but necessary.

Figures III and IV illustrate the same active continuous flow (III) and intermittent flow (IV) tunnels' capabilities for both Mach number and Reynolds' number. Immediately apparent is the large void in our ability to match Reynolds' number and Mach number above a Reynolds' number of 8 million. To illustrate: four current airplanes' speed and Reynolds' numbers for operational altitudes are shown (fig III: C-141, B-707, C-5, B-747) to be way outside present test capability.

Not apparent, in the illustrations, is that both airplanes and wind tunnels present very difficult problems at speeds around Mach 1 where Reynolds' number has even added significance. Our capability to test at adequate values of Reynolds' number near Mach 1 is virtually nonexistent. The next generation aircraft (fig III: fighter, SST, bomber) shown will experience problems here and will require undesirably conservative design until this testing problem is resolved.

Figure III also shows the proposed test envelope of the National Transonic Facility which, when completed, will go a long way toward providing more rigorous answers for future aircraft in the transonic regime. From just this window it can be seen that quite adequate wind tunnel facilities for configuration investigations for civil aircraft exist. This excepts transonic tests at Reynolds' number, and high Mach and Reynolds' numbers tests where temperature problems develop. For speeds up to 0.9M industry and university tunnels are usually adequate for civil aircraft requirements.

Full Scale Engine Installation Testing

Since the beginning of aviation installed engine performance has been the major design problem. Efficiency, payload, range, net power, and fuel economy are always high priority design goals. Military range and civil fuel economy requirements currently amplify these design goals. Jet engine installations operating over a wide range of Mach numbers and altitudes have seldom, if ever, been optimal as installed. Available test

- 4 -

methods are very crude by any engineering standard. Engine air flow, duct flow, and the complex combination of external flows around engine pods, from fan and jet exhausts in the presence of pods, pylons, and airframes can only be optimized by full scale tests as installed at flight speeds, and altitudes.

The Aeropropulsion Systems Test Facility (ASTF) proposed by the Air Force at the Arnold Engineering Development Center becomes essential if the next several generations of transports and military aircraft are to meet advancing requirements. It will be very important to permit the civil air transport industry to have access to this facility with fair priority.

Much has been made of the fact that the "derivative" nature of civil aviation as fall out from military programs has changed in recent years. There is no supportable argument that civil aircraft have ever been military derivatives in any true sense. Conversely, large civil engine developments very rarely are not military derivatives, and this has not changed significantly. It is hard to find important differences in military and civil major engine parameters when comparing civil quiet, high bypass engines to similar military sizes. However, very large benefits can be mutually gained by assuring even closer liaison between military and civil requirements. The ASTF supports that possibility.

Full Scale Vehicle Testing

The third void in development testing capability, similar to the two above, arises for the same reasons as design passes from an art to a science. Full scale wind tunnel testing of powered lift vehicles is very essential for very much the same reasons as is full scale engine, and equivalent full scale transonic air frame testing discussed above. No example of combined aerodynamic and powerplant problems is yet more complex than that experienced with all varieties of powered lift vehicles and rotorcraft. The technical arguments here use the same words as above but may even need more emphasis.

There is no way to optimize design of VSTOL concepts other than to wind tunnel test full scale dynamically similar powered prototypes. VSTOL represents a whole coming industry in which the U.S. is slipping from a favored position. The proposed modification of the NASA 40x80 full scale wind tunnel is a large step toward resolving this shortfall. The return on this investment will prove very substantial.

Again it is very important that the civil aviation industry be given access with fair priority to the 40x80 and the updated 40x80.

- 5 -

A Question of National Policy

A very carefully studied review of national interest should be undertaken with respect to industry access to national facilities for civil applications. Various agencies within the government exchange access to facilities with varied and often confusing charging practice. Industry with military programs has high priority access to NASA and Air Force facilities at no charge. With civil aviation it is another story.

The NASA Unitary Plan was devised to help correct this in the past, but there is no evidence that the plan ever worked that way. Very seldom has industry bought wind tunnel time under the Unitary Plan; never at Langley Research Center per the GAO report. Three elements of national and NASA policy inhibit, nay eliminate, industry access to NASA facilities and expertise:

- 1) No protection of proprietary test results.
- 2) No patent protection for industry innovations.
- 3) Restrictions against export of test results for a fixed number of years.

In short, government policy is contrary to American industry interests under some misguided idea that interests of industry and government necessarily conflict. A policy that permits manufacturers to protect what they invent is in the national economic interest.

A blithe recommendation regarding policy is perhaps out of order here, but a palatable and aggressive policy to encourage industry developments, with access to government facilities and expertise, could very well enhance the U.S. worldwide competitive posture.

A Question of NASA Policy

Very probably the breadth and depth of NASA wind tunnel capability approaches that of the rest of the world combined. The utilization and application of that capability warrants discussion.

One cannot get very excited about the state of U.S. capacity for aeronautical research at all levels. For instance, NASA has been top heavy in wind tunnel capacity below Mach 4 for 15 years. How many various research tests can be done with such a capability before a question of redundancy arises?

However, one could get very excited if a substantial amount of redundant NASA wind tunnel capability were devoted to specific vehicle applications under a cooperative development program with industry. In 1976 the U.S. has no new or innovative

- 6 -

civil commercial vehicles in work to compete with several major and unchallenged foreign products. The urgency to reverse this situation cannot be taken lightly. Failure to do so is unacceptable. If NASA wind tunnels and technical depth were available at some cost to industry, with protection of proprietary and patent rights, the nonrecurring front end development costs of new vehicles could very well be dramatically reduced. It goes without saying, perhaps, that this argument obtains across the spectrum of NASA research.

Useful and effective development is always best when aimed at goals and objectives born of operational and marketable requirements. If NASA aeronautical development is to return to productivity it needs applications requirements as a catalyst. What better national purpose, if in addition to accelerating research productivity, we regain or increase our international market. Lest a great alarm goes up, let's not forget that once the Post Office and the Navy had their own aircraft factories, and conversely, in the 1930's the only research airplanes were privately funded racers. Flexibility between government and industry roles does not need to be invented here.

Balanced R&D

Wind tunnel research is no end unto itself. It is a sterile activity that can be repeated endlessly within itself unless supported by flight test verification to point to fruitless efforts and to new and innovative avenues to explore. Without flight verification many problems are left unknown and unstudied. With the creation of NASA in 1958, the old military and NACA coalition dissolved and flight research virtually became extinct with the demise of the cooperative research airplane program. To do wind tunnel research without complimentary flight research simply means little or no progress.

A substantial cost avoidance in wind tunnel activity would occur with a complimentary flight research activity. There is no claim here that there would be a net dollar saving. A real gain, though, would be in priceless progress in aeronautical performance which has been virtually stagnated since the end of the research airplane program. It is not acceptable to concede that aeronautical progress peaked out in 1960, but by all evidence it would appear so.

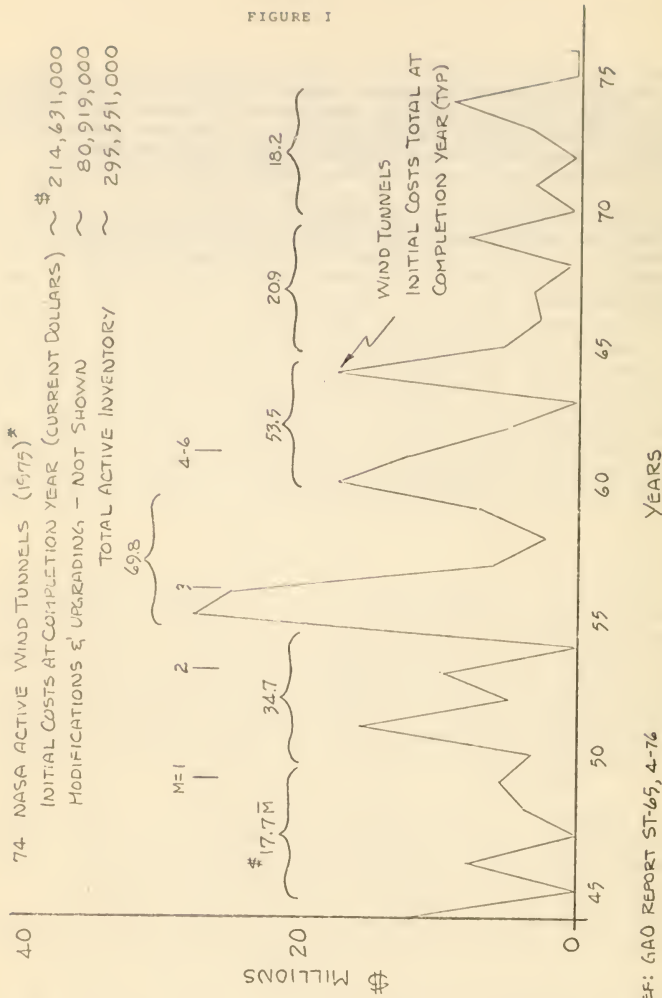
In the last 15 years we have been endlessly running air through wind tunnels, often just refining old refinements, with virtually no expansion of the experimental and military performance envelope in flight. In the 14 years up to 1961 we had expanded speed and altitude performance by a factor of more than six with research airplanes. With military airplanes, speed increased four times and altitude by two. In that time

- 7 -

we surpassed our three traditional foreign rivals and set the stage to capture the world market. Since 1960 the military performance envelope has been static and devoted flight research has virtually disappeared. Coincidentally, or perhaps consequently, comparative overseas aeronautical technology, performance, and market invasion have been on the upswing by comparison.

The foregoing evaluation naturally raises concern for an over balanced R&D policy in favor of wind tunnel research with a graver concern for its usefulness without complimentary flight research, Aeronautical research without aeronautics just doesn't make sense.

FIGURE 1

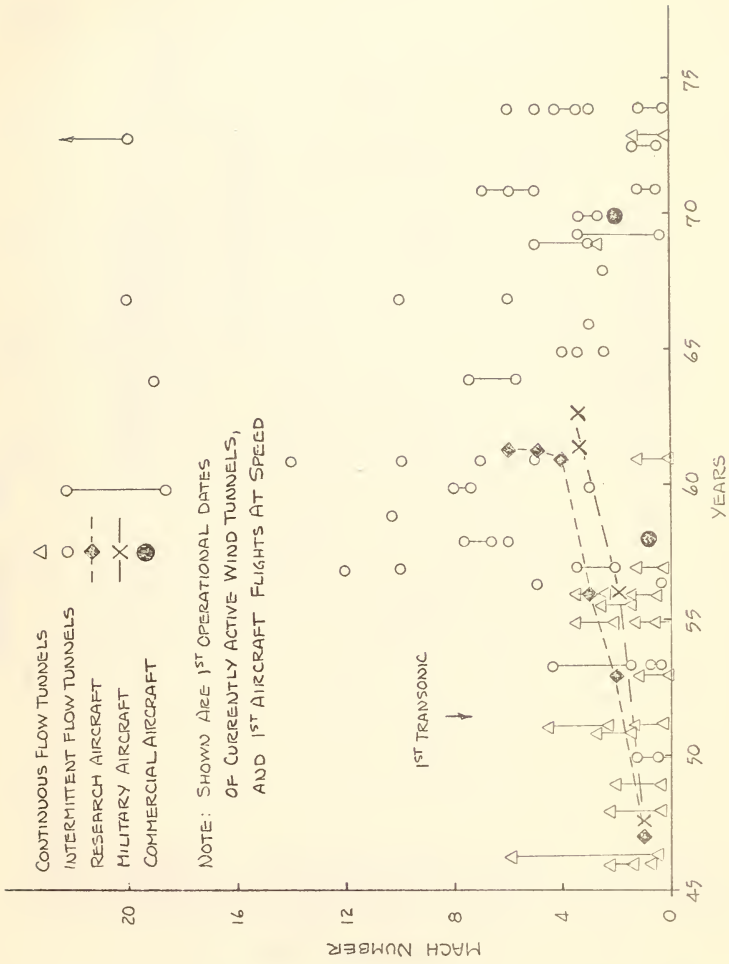


* REF: GAO REPORT ST-65, 4-76

NASA WIND TUNNEL INVENTORY (1975)

- 9 -

FIGURE II



NASA WIND TUNNEL CAPABILITY GROWTH TO 1975

FIGURE III

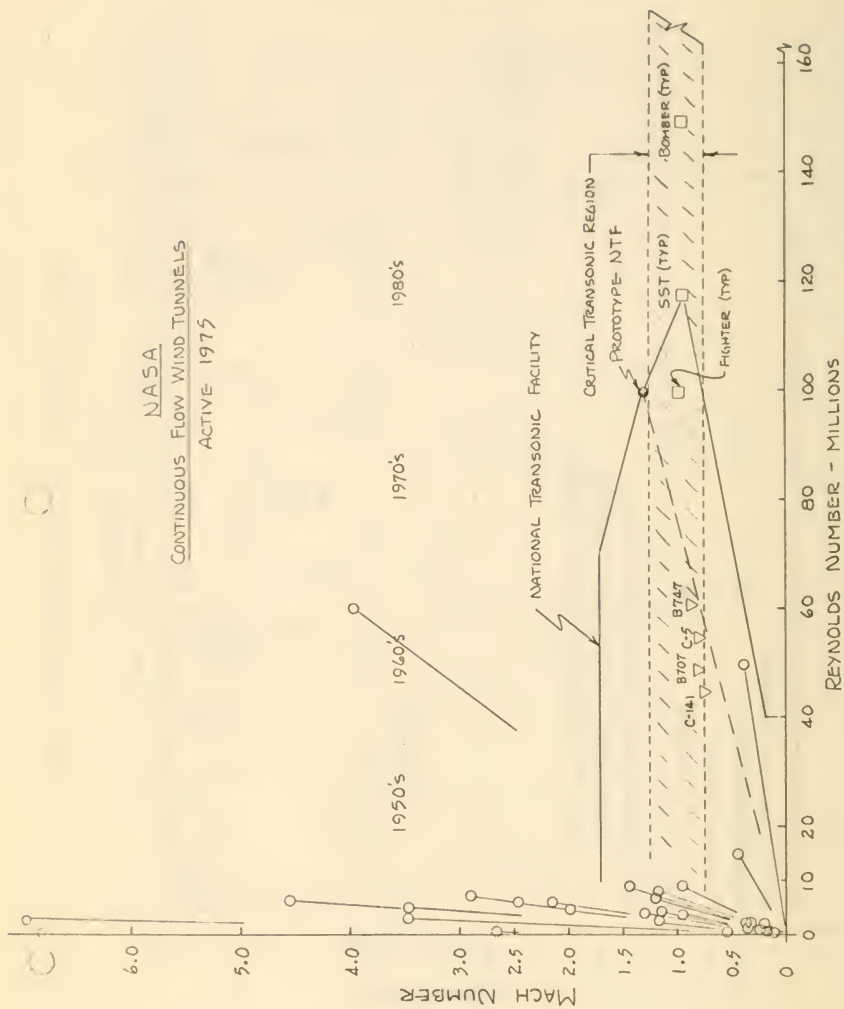
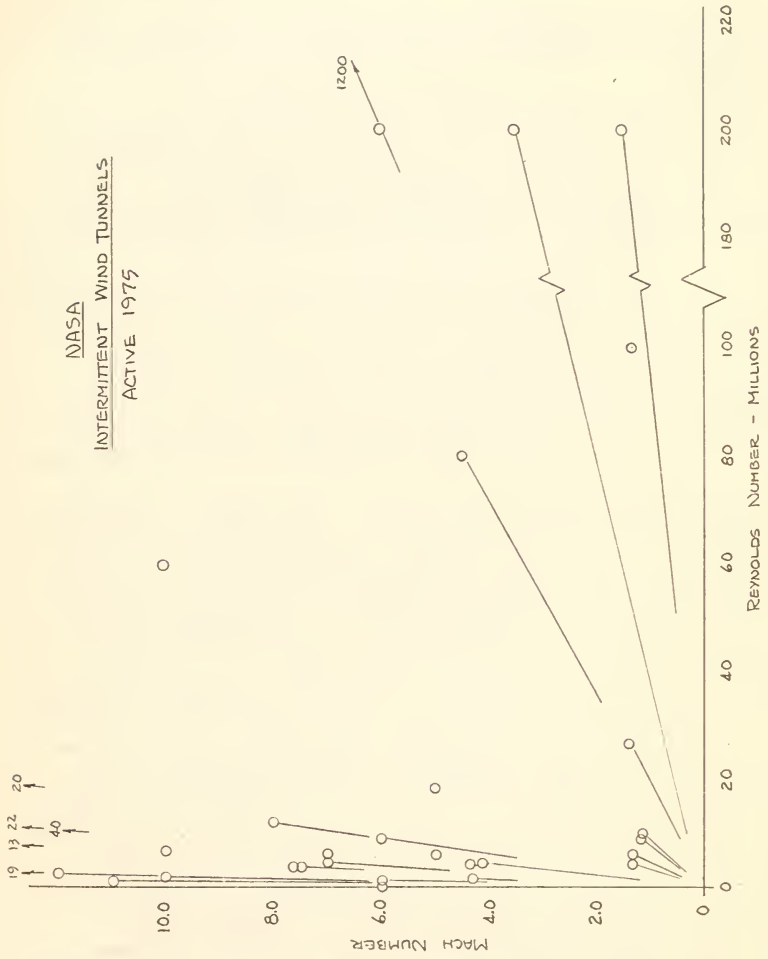


FIGURE IV



SUMMARY AND CONCLUSIONS

I. From this limited review one can draw a conclusion that the government owned wind tunnel inventory is quite adequate for current and currently forecast requirements with notable exceptions:

A. The National Transonic Facility is essential to fill a critical void in transonic high Reynolds' number capability.

B. The Aeropropulsion Systems Test Facility proposed by the Air Force is essential to fill a critical void in engine, pod, duct, and installation experimental capability.

C. The proposed upgrading of the 40x80 full scale wind tunnel is essential to fill a critical void in VSTOL experimental capability.

II. The private sector (industry and the universities) have considerable basic capability. The three areas described above plus high Mach, high Reynolds' number, and thermal capability are generally unavailable in the private sector inventory. It is a strong recommendation of this report that industry access to all national facilities be given high priority with protection of proprietary and patent rights. This recommendation, also, reflects the opinion that the industry should have a voice in priorities involving NASA vs industry interests.

III. Some avenues of NASA research have been going on fruitlessly and repetitively for 55 years. Wind tunnel research, to some degree, has appeared to drift into the mode of research for research' sake. A fascinating experiment would be a cooperative program with industry to pursue specific vehicle applications aimed at expanding specific vehicle types performance envelopes and creating a new generation of national industry products. Intelligently applied the facilities and expertise in NASA could do for the civil market what it does for the military. Arguments for protection of NASA's aloof role from national economic battles should be viewed as pedantic nonsense.

IV. Flight research, the necessary counterpart of wind tunnel research, fell by the wayside in the 1960's and with it went the growth in aircraft performance; that just stopped. The rest of the world caught up and even bypassed the U.S. in some areas where we once had clear superiority. The political atmosphere no longer allows the military to take technical risks. There can be little progress without technical risk unless the results of experiments are validated in research flight and then put to practice. It is strongly recommended that some form of a formal flight research program, complementary to wind tunnel research, be developed into an ongoing national program. Otherwise it must be questioned whether we are getting our research dollar's worth or are taking even partial advantage of a vast idle store of technology and technological investment.

APPENDIX

Digest section excerpted from GAO Report ST-65 entitled:
ACQUISITION AND UTILIZATION OF WIND TUNNELS BY THE NATIONAL
AERONAUTICS AND SPACE ADMINISTRATION, dated: April, 1976

DRAFT

COMPTROLLER GENERAL'S REPORT TO
THE COMMITTEE ON SCIENCE
AND TECHNOLOGY
HOUSE OF REPRESENTATIVES

ACQUISITION AND UTILIZATION
OF WIND TUNNELS BY THE
NATIONAL AERONAUTICS AND
SPACE ADMINISTRATION

D I G E S T

At the request of the Chairman, House Committee on Science and Technology, GAO has examined 74 wind tunnels and related special-purpose test facilities which cost about \$309 million to obtain utilization, operation, and cost data. (See p. 6 .) GAO has identified 45 wind tunnels that have been discontinued. They are either inactive, dismantled and stored, transferred to another Government or private user, or converted to other uses. (See p. 9 .)

UTILIZATION OF WIND TUNNELS

Average utilization of National Aeronautics and Space Administration (NASA) facilities ranged from 59 percent for hypersonic wind tunnels to 76 percent for subsonic wind tunnels. (See p. 6 .)

Several conditions limit utilization of certain wind tunnels. Cost and availability of energy creates inconveniences in that tunnel operations must be scheduled during "off-peak" hours to take advantage of lower rates or because adequate power is not available during regular working hours. Although no critical or high-priority projects have been delayed or canceled due to this practice, NASA officials foresee the availability and cost of energy as a growing problem. (See p. 7 .)

Some locations have experienced difficulties due to the lack of available manpower. Ames Research Center officials stated that the principal constraint to their wind tunnel operation is the nonavailability of manpower and that more than 3,300 requested test hours were denied during fiscal year 1975 because of manpower shortages. (See p. 8 .)

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Year Sheet. Upon removal, the report cover date should be noted hereon.

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Tunnel instrumentation (equipment used to measure and process test data) for some facilities is inadequate. (See p. 8.) The best instrumentation and data processing equipment currently available could reduce the test time to as little as 25 percent of the time now required. The feasibility and cost of upgrading present tunnel instrumentation should be explored in greater depth.

NASA said that it was planning to initiate a study in the very near future on ways to reduce test time and energy usage and that improvements in tunnel instrumentation and data acquisition systems would be included. (See p. 10.)

NASA officials are in the process of eliminating facilities which are no longer needed because their capabilities are duplicated or superseded. In addition, NASA is centralizing its aeronautical research efforts, locating them primarily at Langley and Ames Research Centers. (See p. 8.)

NASA's current efforts to phase out unneeded facilities and centralize operations should further improve its utilization of available facilities.

OPERATING COSTS

The cost to operate NASA's wind tunnel facilities in fiscal year 1975 was about \$18 million with personnel costs accounting for almost half of that amount. Electric power costs totaled more than \$4 million. Maintenance costs also exceeded \$4 million. (See p. 7.)

PLANNED PROCUREMENTS

At the Langley Research Center, NASA plans to construct a high Reynolds number facility--a wind tunnel capable of predicting with confidence full-scale aircraft performance and flow conditions at transonic speeds based on scale model investigations. The facility

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will be known as the national transonic facility and is estimated to cost \$65 million. (See p. 17.)

The national transonic facility will be designed to achieve a 120 million Reynolds number capability, which represents a level about 10 times that of currently operational continuous flow transonic tunnels. According to aeronautical authorities, the lack of a high Reynolds number testing capability is the most critical deficiency in the operating characteristics of U.S. transonic facilities. They further state that extrapolation of data from present facilities has strained the limits of credibility and that viable alternatives to a high Reynolds number capability do not exist.

GAO's review did not include a determination or evaluation of the optimum Reynolds number capability for the proposed national transonic facility. However, based on the preponderance of evidence, increased capability in this area would enhance the technology base and assist in developing more efficient civil and military aircraft. (See p. 16.)

MODIFICATION COSTS

A planned modification to the 40- by 80-foot wind tunnel at Ames has been deferred until fiscal year 1978. The modification is currently estimated to cost about \$85 to \$90 million over a 5-year period. (See p. 21.)

About \$3.8 million was appropriated during fiscal year 1976 for modifications to wind tunnels at Ames, and \$755,000 was requested for fiscal year 1977. (See p. 19.)

AGENCY COMMENTS

NASA found the material in GAO's proposed report to be clear and basically factual. NASA also stated that GAO's opinions and conclusions were generally reasonable. (See p. 19.)

DRAFT

REVIEW OF NATIONAL AVIATION
R&D FACILITIES AND PROGRAMS

FAA FACILITIES AND METHODS

Submitted to

The Honorable Dale Milford, Chairman
Aviation and Transportation R&D Subcommittee
House Committee for Science and Technology

by

A. Scott Crossfield

June 9, 1976

FAA FACILITIES AND METHODS

The Chairman of the House Committee for Aviation and Transportation Research and Development has initiated a Review of National Aviation R&D Facilities and Programs. This report offers observations and recommendations related to two objectives of the subcommittee's Review:

1. Determine whether unwarranted duplication exists in agency aviation R&D facilities.
2. Determine if sufficient attention and resources are being devoted to R&D facilities and programs.

This report, at this stage, limits its observations to the inhouse FAA R&D facilities and programs. The general FAA R&D administration picture regarding these two objectives is obscure until agency response to pertinent requirements is sorted out and clarified.

PARAPHRASED FAA R&D POLICY

FAA R&D policy, must of necessity, include several objectives like:

1. To recognize social and economic trends to determine and plan for their impact on aviation demands.
2. To assure maximum government support to anticipate and implement orderly changes as future requirements develop.
3. To assure that civil aviation is permitted to develop in its own direction, at its own pace, in a safe, orderly, and efficient manner.
4. To assure safe, efficient, and orderly traffic flow for all traffic, in all areas, for all users.
5. To organize and maintain an R&D capability to assure meeting all objectives in a timely manner.

ASSESSMENT OF FAA R&D PRACTICE

Virtually 100% of FAA R&D effort is aimed at safe efficient, and orderly flow of traffic. These efforts have been, and will be effective only to the degree that FAA adequately perceives the requirements and manages its professional and material resources to meet them. The present circumstance of the air traffic system indicates the degree to which FAA meets this challenge. FAA R&D program and resource management is sorely in need of a complete overhaul. It is scintered and scattered throughout the agency. Key areas suffer from serious inadequacies of skill and professional levels.

R&D program management is conducted out of Washington headquarters, divorced from the research and experimental tools of the laboratories. Bits and pieces are "farmed out" to the

- 2 -

laboratories and contractors and it is very difficult to determine program systems management responsibility.

It is axiomatic that R&D programs are successful under a dedicated program management with a dedicated team, co-located with the objective hardware development activity and laboratory tools, to bring research objectives to timely and productive results. It is not evident that FAA recognizes this time worn axiom. The principal and only substantive R&D resource of FAA is NAFEC. But, under FAA management NAFEC is a kind of research condominium with absentee owners. NAFEC provides housekeeping, tools, and craft skills like an independent test and experimental contract laboratory. NAFEC has virtually no R&D responsibility per se. NAFEC, as a consequence, is woefully weak in professional and technical depth. So truncated, with its "brains" in Washington headquarters, NAFEC has not the "clout" to maintain its plant, tools, and capability in keeping with its mission. A further consequence has been a waning competence to meet schedules and program objectives.

A studied reorganization of FAA R&D management, resources, and tools, aimed at a strong R&D systems integration is necessary. This, hopefully, would result in allowing FAA to elevate their inhouse competence sufficiently to bring them up to being in tune with the times and the future. Such a study could very well result in two general recommendations:

1. Consolidation of programs, resources, and facilities to effectively have a manageable, responsible, and productive R&D capability.
2. Require FAA to make the necessary administrative decision to generate the management, professional, and skill levels to meet their national R&D obligations.

It follows that before definitive recommendations can be made a discussion of the several diverse and dispersed FAA R&D activities is in order.

CIVIL AEROMEDICAL INSTITUTE

Under the direction of the Federal Air Surgeon, FAA Office of Aviation Medicine, the Aeromedical Research Branch of the Civil Aeromedical Institute is aimed at research in the biomedical and human performance aspects of civil aviation.

The Aeromedical Research Branch of CAMI is technically well conceived and well managed. It has an enviable depth in a wide variety of scientific skills:

- | | |
|-----------------------------|----|
| 1. Doctorate degrees | 21 |
| 2. Masters degrees (MA/MS) | 19 |
| 3. Bachelor degrees (BA/BS) | 22 |
| 4. No degree | 30 |

- 3 -

Total Personnel

The skill distribution is varied:

Field	Number
Medicine	2
Mechanical engineering	2
Geography	1
Biostatistics	1
Psychology	18
Veterinary	1
Metalurgy	9
Biology	6
Anthropology	2
Computer	1
Business, Education, and Admin.	1
Hearing	1
Mathimatics	1
Educational research	1
Chemistry-Biochemistry	9
Medical technicians	2
Botony	1
Optometry	1
Industrial management	1

Professional personnel	62
------------------------	----

Clearly the Aeromedical Research Branch has put together a very powerful capability.

The CAMI research equipment inventory amounts to some \$4 million and includes chemical instrumentation, environmental and altitude chambers, crash simulation sleds, a water survival tank, a morgue, computers, and air traffic and aircraft task simulators.

Unfortunately, when it comes down to a very hard look at FAA priorities, this gem of a lab is an organization looking for a mission and for a way to fill an under utilized facility. A significant percentage of CAMI research programs and equipment could well be consolidated with related resources at NAFEC. These would be the programs that are design and aircraft equipment oriented. On the other hand, the medical research capability being developed is duplicated in depth in other government agencies and medical foundations which are staffed, equipped, and experienced. It could be very expensive to try to match outside capability.

It is enigmatic to have to conclude that such a well planned and fine potential capability is redundant when matched with other priorities for resources. Aeromedicine is one FAA discipline that is not unique to FAA by far. A quick review of typical programs can illustrate the observation.

- 4 -

Appendix I reviews typical programs with observations as to FAA inhouse requirement to invest in such wide ranging research which duplicates other national capabilities.

There is a proliferation of fire tunnels, impact devices, sled tracks, pressure chambers, centrifuges, materials labs, environmental labs, etc., and of experience and resources in the Army, Navy, Air Force, NASA, and NAFEC, amongst others, that could well respond to FAA requirements for aeromedical answers. In view of this it is difficult to justify additional FAA investment in duplicating laboratories and skills.

TRANSPORTATION SYSTEMS CENTER

In 1969 the NASA phased out as excess its Electronic Research Center in Cambridge, Massachusetts. The entire facility, including a bulk of the personnel, was transferred to the DOT for transportation research as the Transportation Systems Center.

Early on, in 1971, nearly 60% of TSC activity was civil aviation oriented, put there as a supporting subsidy by DOT. The level of activity has remained fairly constant but proportionately has dropped to about 20% of TSC activity by 1975.

TSC has made available a high level of technical skills. About \$66 million of civil aviation R&D has been placed there for fiscal years 1971 through 1975. TSC places about 52% of this effort out to contractors. Of some 660 personnel, 455 are professional. 32 employees are assigned to the Aeronautical Systems Division and another 133 from other departments are working on civil aviation R&D projects (1975). Of the 32 assigned, 24 have technical bachelor and advanced degrees.

Dedicated and shared facilities for civil aviation R&D include:

1. Communications channel measurement, simulation, and test facility covering communications over the transportation spectrum of requirements including satellites.
2. Ground and airborne ATCRBS tracking laboratory and antenna arrays.
3. Automated FSS facility simulator.
4. Cockpit simulators.
5. Mobile laboratories for data processing.

The effect of supporting TSC has been to further disperse FAA R&D effort, complicate program management, and dilute the requirements incumbent upon NAFEC to bring it up to essential capability. If FAA is, in fact, going to have a competent in-house R&D capability it is essential that they consolidate their dispersed activities into an integrated whole that can be identified as responsible for results. Proper R&D manage-

- 5 -

ment cannot otherwise be accomplished.

Appendix II reviews major TSC program activity and assesses its placement. The conclusion from review of TSC programs revolves us back to the argument of full utilization of NAFEC and the severe short fall in FAA R&D administration. An approximation of FAA R&D resource distribution is illustrated on page 6. Also shown, for illustration, are the FAA facilities and program distribution between NAFEC and TSC. In spite of a rather substantial facility capability on paper, the NAFEC possesses an aging aircraft fleet and a need to update technically aging laboratories, which are diminishing in ability to respond to advancing needs.

SUMMARY DISCUSSION

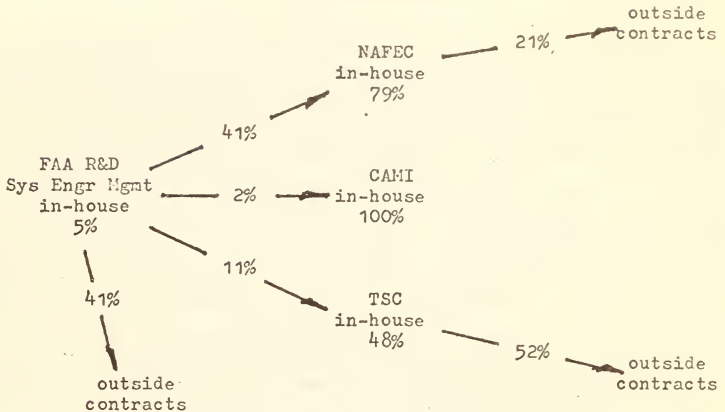
It is not at all clear that FAA understands the criticality of competence and continuity in the series activity of advanced planning, conception, feasibility analysis, specification, design, building, installing, and managing of new and innovative systems. Their year by year falling behind the industry requirements for new ATC technology has become one of the major impediments upon aviation growth and prosperity.

There has been, for sure, limitations upon available R&D resources, but again, this partially stems from FAA inability to make a cogent case of national need to obtain the necessary appropriations. The creating of a consolidated, in depth, research capability would well serve to develop a clear and productive argument for an adequate R&D budget as well as develop the capability to accomplish timely and productive research.

It is argued here that NAFEC, in spite of its manifest shortcomings, is a very substantial base upon which could be built a necessary national resource. The NAFEC has an ideally located hardsite facility with vast unused capability and capacity. It is a unique microcosm of the variety of world wide terminal and enroute systems. It could, if properly managed, be a research and development center unequalled around the world, and in turn would recover the FAA lagging position.

- 6 -

DISTRIBUTION OF FAA RESEARCH, ENGINEERING & DEVELOPMENT RESOURCES
(Airport and Airway Trust Fund)



FAA R&D FACILITIES APPLICATIONS

FAA Engineering and Development Program number

NAFEC Facilities	01	02	03	04	05	06	07	08	12	13	14	15	16	17	18	20	21	11
Aircraft	X	X	X	X	X	X	X	X	X	X	X	X		X	X			
Airfield	X	X	X	X	X	X	X	X	X	X	X	X		X	X			
Range Instr/meas			X	X	X	X	X	X			X	X		X				
Simulation	X		X	X	X	X	X	X	X	X	X		X			X	X	
Surveillance Radar		X	X					X	X		X							
Com/Nav			X	X	X	X	X	X			X	X		X	X	X	X	
ATC Sys Lab			X						X		X							
Data Processing	X	X	X	X	X	X	X	X	X		X	X		X	X	X	X	
Air craft Safety								X							X	X		
Lab Service	All program areas as required.																	
Transportation																		
Systems																		
Center		X		X				X	X		X		X		X		X	X
Legend:	01	System						08	Arprt/Arsd				15	Av Wx				
	02	Radar						09	Arprt/Lndsd				16	Technology				
	03	ATCRBS						10	Oceanic				17	Satellites				
	04	Navigation						11	ATC Com Cntr				18	A/C Safety				
	05	ASA						12	Enrt Cntr				19	Av Med				
	06	Communications						13	FSS				20	Env Prctn				
	07	Apprch & Lndng						14	Trm/Trw				21	Support				

- 7 -

RECOMMENDATIONS

FAA urgently needs a consolidated research and development central activity held responsible for R&D plans and the planning, design, implementation, and timely results of FAA R&D requirements to the point of deployment to the field. The Administrator must recognize the need and implement the necessary actions on an urgent basis. Actions may appear thus:

1. Assign a well defined charter and authority to a management team which understands good productive R&D management and methodology.
2. Establish a consolidated R&D center responsible for total FAA R&D activity.
3. Transfer headquarters R&D activities to the consolidated center.
4. Transfer CAMI physical experimental programs and skills into related labs at the consolidated center.
5. Transfer TSC related programs, facilities, and skills to the consolidated center.
6. Pull back inhouse a sufficient amount of outside contract work to maintain a well balanced inhouse capability for both program management and technical control.
7. Charge and hold the consolidated center responsible for definition of FAA R&D programs, professional skill levels and performance, and justification for appropriations.
8. Reduce to a minimum the tenant laboratory resident practice and place them under the responsibility of Center management.
9. Get on with the 15 year old Facilities Improvement Plan along with updating basic laboratory tools.

This report would recommend that NAFEC offers an ideal base for an effective consolidation of FAA R&D resources.

APPENDIX I
ASSESSMENT OF CAMI RESEARCH PROGRAMS

Physiology Laboratory

1.) Survey of Intermediate Vision Problems of Senior Pilots. The Air Force, Wright Field, Aero Medical Lab, The School of Aviation Medicine, Navy establishments, and foundations like the Lovelace Foundation among many, have depth, interest, and experience of years with this problem and could well serve the requirement.

2.) Protection of Flight Attendants from Hypoxia Following Decompression. The requirement to determine how soon supplemental oxygen is required after decompression has been studied to death for many years by the Military and medical foundations like Lovelace. The equipment design and operational procedures are a NAFEC job.

3.) Development of Aviation Stress Protocol-Simulation and Performance, Physiological, and Biochemical Monitoring System. Again the Military and private foundations have been doing similar work for years, are equipped and experienced in both military and civil problems.

4.) Stress in Air Traffic Controllers. The tools for these studies are at NAFEC and in the field.

Toxicology Laboratory

1.) Toxicological Examination in Accident Investigation. Purely a data gathering program, though probably requires medical analysis.

2.) Pathology in Aircraft (accident) Investigation. A significant aviation safety item of interest to the Military.

3.) Development of Analytical Methodology for HCN and Determination of Tissue Concentration. This implies detailed research in some animal and human medical lab. The GAO description describes test and analysis of cabin materials subject to fire. This is purely a chemical-mechanical experimental requirement not far afield from NAFEC related capability.

4.) Effects of Problem Drugs on Neural Mechanisms in Animals and Man. This general subject has widespread activity and, again, resources and experience are available in the Military and civil institutions.

5.) Radio Biological Safety Requirements in the National Aerospace Program. This subject has been studied to death. NASA, White Sands, USAF, and Lovelace have been measuring personnel and pilots for twenty-five years.

Psychology Laboratory

1.) Stimulus Parameters of Visual Approach. The tools for this program are at NAFEC.

2.) Comprehensive Assessment of Air Traffic Controller Selection Factors. Necessary to the Federal Air Surgeon's inhouse responsibility and also responsibility of the Oklahoma City Center.

3.) Effects of Congener vs Non-Congener Alcoholic Beverages on Performance in Stationary and Moving Environments. This is so general and far out that it is university oriented.

4.) Development of Performance Measures for Aviation Stress Protocol Simulation. Again this has the familiar ring of military and civil research in spades. The interest, capability, and experience is available in and out of government.

Protection and Survival Laboratory

1.) Testing and Evaluation of Oxygen Masks and Systems for High Altitude Decompression and Respiratory Protection in Toxic Smoke and Fire. Only the results of physical-mechanical tests are medically oriented. There is a wealth of background in the military and civil labs and such tests may well be done outside or at NAFEC with much less duplicate facilitization.

2.) Investigations of Materials and Techniques to Reduce Crash Injury. This subject of restraint and impact attenuation has been studied in depth by all sectors including all of the Military, NASA, private sector etc. and should be continued. However, it is a mechanical and materials investigation program better done where tools and experience are available.

APPENDIX II
ASSESSMENT OF TSC RESEARCH PROGRAMS

03-Beacon, Air Traffic Control Radar Beacon System (ATCRBS). The tools and facilities for this program along with related interface programs and facilities are at NAFEC. The technical skills should be assigned with the program there.

04-Navigation, Short Take-Off and Landing (STOL) Navigation and Guidance Study. This is purely NAFEC responsibility along with having all the tools in place.

05-Collision Avoidance System, Proximity Warning Indicator (APWT). Clearly the NAFEC facilities relate and contain interfaces.

06-Communications, Air-Ground Data Link Development. Same comments re NAFEC.

07-Approach and Landing Systems, ILS Performance Prediction. Again, could clearly be placed at NAFEC given the professional billets; the facility capability is there.

08-Airport/Airside, Airport Wake Vortex Avoidance. Same comment.

Airport Surface Traffic Control. Same comment.

16-Technology Future Data Processing. NAFEC understanding of the problem could well have born more productive results.

17-Satellites, Aeronautical Satellites System. This kind of advanced research may well be placed out by FAA, but eventually must be tested against the ATC system at NAFEC. Had NAFEC an adequate technical depth, such a program would well profit from integrated R and D program management up to qualification against the system.

DOT Sponsored Project, Advanced Air Traffic Management System.

Here is a classic example proclaiming admission of FAA low level of R and D competence. For a using organization to go outside to define its mission and requirements, particularly when it allegedly is unique in its own expertise, raises a discomfiting spectre. The results of the program were informative and thoughtful, but of questionable value for \$9.4 million dollars.

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